Aalto University
School of Engineering

Eero Järvenpää

Development of a dynamic performance-based distribution scheme for bulk shipping pools

Thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Technology

Espoo, 4.2.2016
Supervisor: Professor Pentti Kujala
Advisor: Jouni Salo, M.Sc. (Tech.)

Aalto University
School of Engineering

Aalto University, P.O. BOX 11000, 00076 AALTO
www.aalto.fi

Abstract of master's thesis

Author Eero Järvenpää		
Title of thesis Development of a dynamic performance-based distribution scheme for bulk shipping pools		
Degree programme Mechanical Engineering		
Major Naval Architecture		**Code** K3005
Thesis supervisor Professor Pentti Kujala		
Thesis advisor Jouni Salo, Product Manager, Shipping Solutions		
Date 04.02.2016	**Number of pages** 62 +19	**Language** English

Abstract

Shipping industry is the vehicle behind global economy enabling the transportation of large quantities of raw materials, products and commodities to almost anywhere in the world with unit costs and unit emissions unattainable by any other mode of transport. While the unit cost and unit emissions of seaborne transportation are substantially low, the shipping industry is far from being a green industry and there is a lot of room to improve the energy efficiency and to reduce emissions of shipping.

The scattered shipping industry has a wide variety of practices to improve its energy efficiency from basically non-existing to high-tech solutions with real-time-monitoring and advanced utilisation of big data tools. This study concentrates on shipping pools, their operational energy efficiency and how it relates to their distribution schemes. Shipping pool is the primary form of co-operation between shipowners.

This study investigates the currently prevailing distribution schemes for shipping pools and proposes a new way of accounting for operational energy efficiency utilising the Energy Efficiency Operational Index EEOI as the key metric.

This study also opens the discussion of including the pool management into the distribution scheme and proposes a way of doing so. The calculation principal is based on freight values, which are for the purpose of this study approximated using WorldScale-index, and key performance indicators for pool fleet's cargo carrying capacity and time utilisation rates.

The resulting dynamic performance-based distribution scheme is evaluated using operational data from 5 Very Large Crude Oil Carriers, of which an exemplary shipping pool is constructed. The study period for the on-board measurements is the first nine months of year 2015.

The results differ, as expected, from industry-standard solutions by emphasising the operational energy efficiency and fleet utilisation for ships and management, respectively. The collapse of oil price preceding the study period introduced significant variations into the fleet operations and thus the results. Nevertheless, the system accounted for such big fluctuations without issues for both vessels and management.

The novel contributions of this study are the proposal of the dynamic distribution model for ships to replace simple speed and fuel consumption figures of currently prevailing systems, as these neglect the overall operational efficiency; and the dynamic model for management profits as a method to balance-out the ship-focused mind-set of pool distributions and to provide a basis for more open discussion towards energy efficiency and performance monitoring and its benefits in the context of shipping pools and shipping in general.

Keywords Shipping, Shipping Pool, Dynamic, Distribution scheme, Profit sharing, Energy Efficiency Operational Index, EEOI, Bulk Shipping, Maritime, Pool management

Tekijä Eero Järvenpää	
Työn nimi Dynaamisen suorituskykyperusteisen voitonjakosysteemin kehittäminen varustamopoolille	
Koulutusohjelma Konetekniikka	
Pääaine Meritekniikka	**Koodi** K3005
Työn valvoja Professori Pentti Kujala	
Työn ohjaaja Jouni Salo, Tuotepäällikkö, Shipping Solutions	
Päivämäärä 04.02.2016 **Sivumäärä** 62 + 19	**Kieli** Englanti

Tiivistelmä

Merenkulkuala mahdollistaa suurien raaka-aine-, tuote- ja hyödykemäärien kuljettamisen lähes kaikkialle maailmassa hyvin alhaisilla, muiden kuljetusmuotojen saavuttamattomissa olevilla yksikkökustannuksilla ja -päästöillä. Tästä huolimatta merikuljetusalalla on paljon parannettavaa energiatehokkuudessa ja päästöjen määrässä.

Alalla on lisäksi hyvin hajanaiset käytännöt ja toimintatavat energiatehokkuuden parantamiseksi. Nämä vaihtelevat olemattomasta edistyneisiin reaaliaikaseuranta- ja data-analyysityökaluihin. Tämä tutkimus keskittyy varustamopooleihin, niiden voitonjakoperusteisiin ja operatiivisen energiatehokkuuteen. Varustamopooli on laivavarustamoiden ensisijainen yhteistyömuoto.

Tämä tutkimus tutkii käytössä olevia varustamopoolien voitonjakojärjestelmiä ja ehdottaa uuden, dynaamisen laskentavan käyttöönottoa, jossa hyödynnetään operatiivisen energiatehokkuuden EEOI-indeksiä keskeisenä mittarina.

Tämä tutkimus avaa myös keskustelun varustamopoolimanagerin liittämiseksi osaksi voitonjakelujärjestelmää. Laskuperiaate perustuu rahtisopimusten arvoihin, joita tätä työtä varten on approksimoitu käyttäen WorldScale-indeksiä, sekä poolilaivaston lastikapasiteetin ja ajan perusteella muodostettuja käyttöastearvoja.

Kehitettyä dynaamista suorituskykypohjaista voitonjakojärjestelmää arvioidaan virtuaalisen varustamopoolin ja siinä olevien oikeiden rahtilaivojen operointidatan perusteella. Esimerkkipooli koostuu viidestä erittäin suuresta raakaöljytankkerista (engl. VLCC). Tutkimusjaksoksi valittiin vuoden 2015 ensimmäiset yhdeksän kuukautta.

Tulokset odotetusti poikkeavat nykyisin käytössä olevista ratkaisuista. Tämä näkyy energiatehokkuuden ja laivaston käytön korostumiseen laivojen ja poolimanagerin pisteytyksessä. Tuloksissa näkyy myös selvästi raakaöljyn hinnan romahdus tutkimusjaksoa edeltävien kuukausien aikana, mikä johti merkittäviin kuukausittaisiin vaihteluihin laivojen käyttöasteessa ja siten myös tuloksissa. Kehitetty järjestelmä ottaa tämän tyyppiset suuret heilahtelut huomioon, eikä aiheuta ongelmia järjestelmän ollessa lähtökohtaisesti dynaaminen.

Tämän tutkimuksen uutuusarvo on ensisijaisesti ehdotetun dynaamisen voitonjakomallin ominaisuus ottaa alusten operoinnin kokonaistehokkuus huomioon yksinkertaisten nopeus- ja polttoaineenkulutuslukemien sijaan. Toisekseen dynaaminen malli tarjoaa tavan sisällyttää poolimanageri voitonjakojärjestelmään tasapainottamaan laivakeskeistä ajattelutapaa varustamopoolin voitonjaossa ja luomaan pohjaa avoimemmalle keskustelulle suorituskyvyn seurannasta ja siihen vaikuttavista tekijöistä niin varustamopooleissa kuin yleisemminkin merenkulun puolella.

Avainsanat Varustamopooli, Laivanvarustus, EEOI, Dynaaminen voitonjako

Preface

The initial idea of developing a dynamic distribution system as a thesis subject occurred, while working at NAPA, during a presentation by an industry representative, Håkan Hasselberg, who was presenting industry insights of tanker shipping and shipping pools.

The goal from the start was to find a solution for an inherit issue in traditional shipping pool distributions, as they tend to not account for real-life-performance and efficiency in a fair manner. The secondary goal was to shed some light on the very discreet area of shipping.

My humble gratitude for supporting me during the making of this thesis goes to my instructor, Jouni Salo. He has been very supportive, providing help accessing critical contacts, information and industry insights, that would have been otherwise very difficult to acquire.

My supervisor, Professor Pentti Kujala, has been extremely patient and flexible, as the timeline of completing this thesis exceeded everyone's expectations. The feedback from him has been essential, especially in the beginning when formulating the topic, and at the end when finalising the work into an academic format.

Huge thanks belongs also to Panu Helamaa, Lauri Hemming, Jutta Seppänen, Liisa Ropponen, Henrik Gahmberg, Nora Gahmberg, Professor Tom Fitzhugh at Texas A&M, and sources wishing to stay anonymous, who all have provided essential background information in one form or another.

I would like to also thank my parents and my sister Marja, who have all been very supportive during the making of this thesis.

I also want to thank NAPA and its staff in Helsinki office, for providing tools, access to information and funding for this thesis.

As this thesis concludes one huge chapter in my life, it is with gratefulness I look back into the years at Aalto University and everything it has given me from education to awesome friends and opportunities to travel the world to see how the world really is.

Eero Järvenpää

Espoo 4.2.2016

Table of Contents

Table of Figures

Table of Tables

List of abbreviations

Abbreviation	Unit	Description
AFRA		Average Freight Rate Assessment
AG		Arabian Gulf
AIS		Automatic Identification System
BAU		Business As Usual
C	[mt]	Amount of Cargo
CC	[mt]	Cargo Carrying Capacity
CCC	[m^3]	Cargo Cubic Capacity
COA		Contract of Affreightment
D	[nm]	Distance
Dwt	[mt]	Deadweight ton
EEDI		Energy Efficiency Design Index
EEOI	[mt_{co2} / (mt_{cargo} * nm)]	Energy Efficiency Operational Index
FFA		Future Freight Agreement
FV	[$]	Freight Value
GHG		Greenhouse Gas
GRT	[rt]	Gross register tonnage
IMO		International Maritime Organization
IPO		Initial Public Offering
KPI		Key Performance Indicator
LNG		Liquefied Natural Gas
MARPOL		The International Convention for the Prevention of Pollution from Ships
MPT	[nm / mt_{fuel}]	Miles per ton of fuel
NRT	[rt]	Net register tonnage
PCC		Pure car carrier
PMC		Pool Management Company
Q1, Q2, Q3		Quarter of the year, equal to three months
TM	[mt_{cargo} * nm]	Ton-mile; unit of transportation work
TUR	[%]	Time Utilisation Rate
UNCTAD		United Nations Conference on Trade and Development
VCUR	[%]	Voyage Capacity Utilisation Rate
VLCC		Very Large Crude Oil Carrier
Worldscale		Industry standard measure of freight rates for tankers

Unit	In SI-units	Description
nm	1,85200 km	nautical mile
rt	2,83 m^3	Register ton

1 INTRODUCTION

The motivation for this study is based on a personal notion of the fact that maritime industry is lagging in some cases even decades behind the air and road industry in terms of utilising the latest technologies and methods. One of the key reasons for this may be the very long and tradition-rich history of the maritime industry. Some of the conservativeness is partly due to the habit of “keeping it on the safe side” has undoubtedly been a good practice when it comes to seafaring. Unfortunately, this also means that the vast majority of industry is risk-averse, slow in its moves and its willingness to adopt or even try new ideas is low. The shipping has also managed to largely avoid the public eye and for a long time to be excluded from European and global climate change measures and agreements, until the sixth Annex of MARPOL came into force in May 2005. (1).

Shipping forms the backbone for the international modern economy, and while it is very cost effective in terms of unit cost and emissions per ton-miles when compared to any other mode of transport, it is far from being pareto-optimal or eco-friendly, as it still uses massive amounts of dirty heavy fuel oil to propel the raw materials, commodities and products around the world. That being said, there is a lot that can be done to improve the overall energy efficiency and reduce the environmental impact of shipping.

With this as a background it is not only enough for one to create new ways of working or invent new technologies for maritime sector, which is the reason why the business-side is kept closely in mind, and self-incentivizing financial characteristics are built into this study. Readiness to being implemented in real life is the ultimate aim– although being a tall order for a master’s thesis.

1.1 SHIPPING – THE VEHICLE BEHIND GLOBAL ECONOMY

Three quarters of the Earth’s surface is covered by water, making it only natural that majority of the worldwide trade is based on seaborne transport. The developments in the rail, road and flight transport have certainly had a huge impact to the marine transport, but it is very unlikely that any of these alternatives will ever be able to compete with the magnitude of cargo transported in relation to used resources. In other words, the unit-cost and overall efficiency of marine transport is beyond compare, thus being the main reason why shipping is estimated of being responsible for some 95% of goods transported in the world. (2) (3)

As marine transport is based on ships, the transportation of goods and people, term *shipping* is widely used in this context. Nowadays *shipping* also means any type of transportation of goods and only context will tell, whether a “shipping company” in question is an actual shipping company or a general transportation service provider, i.e. UPS or DHL. In this study *shipping* is used solely to describe ship-related modes of transportation.

There have been two major technical revolutions in the shipping industry since mid-1960’s: the unitization of general cargo and the evolution of modern bulk shipping – both of which have played essential part in the commodity and raw material markets becoming truly global. The next possible step is already in sight, as there is ongoing research and development to move raw materials into mega containers. (4)

Dry bulk ships have increased in size ten-to-fifteen-fold from 1945 to 1995, whereas the oil tankers have grown as much as twenty times larger during the same period. (4) Since the writing of Martin Stopford's Maritime Economics, the trend of increasing ship sizes has continued bringing us today's supertankers of over 500 000 dwt and container vessels of over 20 000 TEU capacities.

During the past 25 years there have been drastic changes in the way the bulk shipping markets operate – both dry and wet bulk. Whereas historically shipowners have been settled for the role of a price-taker in the buyer's market, consolidation and cooperation in the form of pooling have enabled shipowners to take a more active role, in order to stabilize and improve both their service offerings and profitability.

Prior to the tanker boom in the late 1960's and the bust in the early 70's oil majors – so-called "Seven Sisters" constituting of Esso, Shell, BP, Mobil, Texaco, Gulf and National Iranian Oil Co – were responsible for controlling a clear majority of the oil transportation by sea. They operated their massive fleets of owned and time-chartered tankers. As the market overheated and collapsed in 1973, the oil majors saw the risks of operating their own fleets in a market with volatile demand. This lead to oil majors beginning to outsource their transportation by selling their fleets and buying the transportation as a service on the spot market. This change of focus in commercial operations from long-sighted strategy to short-term trading profits lead the oil majors to realise their bargaining power against the shipowners. Market that used to be described by characteristics of "benign respect of the independent, competitive market place" now became harsh and stormy place for shipowners that historically have been independent, small and typically family-owned companies.

Similar phenomenon happened on the dry market, as the major steel companies, iron-ore producers and grain-houses started growing, gaining global reach in comparison to the fragmented shipping industry.

During the last 20 years, World has seen the emergence of shipping companies like Teekay, Frontline and Scorpio Tankers with focus and ambitions previously unseen. These IPO-driven (Initial Public Offering) companies have changed the course of shipowners and started to level the field against the huge charterers using their new approach to shipping business with fleets many times bigger than previously seen by traditional shipping tycoons. As a side effect, such large companies introduce the risk of bringing down the financiers behind them, should they run into deep financial issues or even go bankrupt.

The consolidation has been going on also in the ship management business, where very large and focused companies like V-Ships, Columbia, Hanseatic and East Asiatic, with fleets up to hundreds of ships, have emerged to offer significant economies of scale – previously unseen for operators.

Shipping pools have been in the forefront of the similar consolidation process of commercial management of ships, and exist now on almost all bulk shipping markets from crude oil to LNG and LPG trades. This has been a game-changer in the attitude of ship operators, who traditionally have been accepting the common situation, where the operation itself barely breaks-even, and the only major profits may be done by buying and selling ships. (5)

1.2 INTRODUCTION TO SHPPING POOLS

Pooling is a form of co-operation between shipowners, who give the *pool manager* the operational responsibility of finding employment for their ships. About 17% of world's tanker fleet of over 10 000 dwt and 10% of dry bulk fleet are commercially operated in pools, so it is by no means insignificant phenomenon. (6)

As pools have variety of ships with different characteristics, it has been found that some kind of system of figuring out the fair share of profits for each party is necessary in order to work together. These profit sharing systems are called *distribution schemes*, which have multitude of variables for the ships' size, capacities and equipment to calculate the *pool points* for each ship. (7)

As these distribution schemes are very much determent to shipowners income, it is of course a matter of a great interest for both current pool members and also for those, who are interested in joining an existing pool or forming a new one.

1.3 OBJECTIVES OF THE STUDY

The objective of this study is to develop a dynamic performance-based distribution scheme for a bulk shipping pool, meaning that the distribution shares of each shipowner are not only determined by the characteristics of the ship, but also how energy efficiently the ship is operated in relation to the amount of cargo is carried.

The secondary objective is to investigate the inclusion of pool manager into the profit-sharing scheme in order to highlight its key role of responsibility in the daily operations and profitability of the pool.

The tertiary objective is to keep the proposed solutions on such a level, that it would be easy to implement in a real world and should not need an excessive instrumentation or special programs – the basic idea is that MS Excel should suffice given that necessary operational data is available from ships.

1.4 SCOPE OF THE STUDY

The work proposes a novel calculation system, that is based on a set of K*ey Performance Indicators (KPI)*, *Energy Efficiency Operational Index (EEOI)* and partly prelevant distribution schemes, as presented by Haralambides (8) and Packard (7).

The scope of this work is limited to consider bulk-shipping pools – both dry and liquid – operating in the tramp and industry shipping markets. The pool distributions are investigated using a virtual crude oil tanker pool, but there should be no restrictions on the validity of the findings to be implemented in other parts of the tramp shipping industry with only minor adjustments.

The main point of view is technology- and business-driven, and for example legal, insurance and financing aspects are not in the scope of the study.

1.5 STRUCTURE OF THE WORK

This study consists of seven chapters:

In the first chapter, an introduction to shipping and shipping pools with relevant definitions are given complete with the objective and the scope of the study. The acknowledgment of research funding is included, also.

The second chapter gives an overview of the shipping industry and its characteristics concentrating on bulk and tramp shipping sectors.

The third chapter gives an overview of the typical shipowner economics from business-technical viewpoint and describes the relevant parts of energy efficiency legislation of International Maritime Organization, IMO.

The fourth chapter describes the workings of a shipping pool as well as the typical distribution systems used in pools.

The fifth chapter presents the construction of the exemplary tanker pool and the dataset used to evaluate the developed distribution scheme.

The sixth chapter presents the created dynamic performance-based model and the theory behind it and continues to analyse how it compares against the prelevant systems.

The seventh chapter presents discussion and concluding words about the study as well as the proposals of further study areas.

1.6 ACKNOWLEDGMENT OF RESEARCH FUNDING

This work was conducted as a master's thesis at the Department of Applied Mechanics of Aalto University, as a concluding work of naval architecture and business studies.

The research was funded by NAPA – a Finnish Maritime IT Company. NAPA has played a vital role providing high frequency big data for research purposes. The work itself is not tied to NAPA or its products, as the proposed distribution scheme can be applied with or without NAPA products given that the necessary data is available by other means.

As the role of used operational data is exemplary in this work, the study does not concentrate on the data gathering or analysis done by NAPA, but relies upon its usability as business-as-usual.

2 SHIPPING INDUSTRY

This chapter gives an overview of the shipping industry, its characteristics, contracts and players involved in the shipping business concentrating on the bulk shipping sector.

2.1 SHIPPING MARKETS

Shipping industry is one of the most international and global industries. While the different parts of shipping industry share common characteristics, there are many sub-markets with own distinct characteristics. First we will establish the existence of 5 distinct markets according to the broad characteristics:

a) freight market,
b) new building market,
c) second-hand market,
d) scrap market, and
e) ship finance market.

Freight market

Freight market is the driver behind the shipping industry and the underline purpose of its existence. Freight market is divided into two major categories according to the size of shipment, *parcel*:

- General cargo market – with less than ship-sized parcels; and
- Bulk cargo market – with ship-sized (or larger) parcels.

The key distinction here is that on the bulk market the ships usually carry only one cargo for one customer, whereas general cargo ships are loaded with multitude of different cargoes for many customers. Some exceptions exist, as it is the case for some chemical product tankers, which are fitted to carry tens of different cargoes in separate tanks. As a general rule the definition applies to vast majority of seaborne cargo, though.

New building market

The newbuilding market is where the shipyards offer and build ships for the shipowners. The newbuilding market is volatile with the demand and prices fluctuating from rock-bottom to sky-high depending on the demand and the phase of market cycle in the global freight market, and the supply of ships in the world fleet.

The fluctuations are exemplified by the fact that the market situation can change many times after a ship is ordered by the time it is delivered. Shipbuilding history is filled with brutal examples of over-estimations leading to bankruptcies.

Second-hand market

Second-hand market is where existing ships are being sold and bought. As the second-hand market is closely connected to the other markets, the price of a used ship can vary from nearly that of a scrap metal all the way up to more than that of a new build. These extremes are explained by two examples:

If markets are low and there is an oversupply of ships, the scrapping value may exceed the second-hand value, as there is very low or no demand for it as a ship.

If on the other hand the the freight market is booming and there are not enough ships available, shipowners are ready to pay premium to acquire a ship, that is readily available rather than being first built, which may take months to a couple of years, depending on the order book situation at the shipyards. Thus, the price for a second-hand ship may exceed that of a newbuild.

Scrap market

Scrap market is where the ships end up when their second-hand value drops close to that of scrap metal price. The ships are being sold, typically to scrapping companies located at the shores of India and Bangladesh, where the ships are beached and taken apart, usually in hazardous conditions. Fortunately, *IMO* is working with *International Labour Organization* and the *Conference of Parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal*, in order to minimize environmental, safety and occupational health risks related to scrapping of ships. (9)

Ship finance and derivatives market

Ship finance market – the addition made to the previous four by Stokes (10) – is the area of business that deals with the financing aspect of shipping and shipbuilding, both of being very capital intensive areas of commerce. Banks, finance institutions and other investors are the key players in this area. In addition, a variety of shipping-related derivatives, such as forward freight agreements (FFA) and bunker derivatives are traded speculatively by both players within and those outside the actual shipping markets. These are also used to hedge future risks by shipowners.

2.2 6 SEABORNE TRADES

In order to understand the drivers behind the shipping industry, one must acknowledge the different needs for sea transport, which are broken into six distinct trades, according to Stopford (4).

Energy trade

Energy trade is the single most important area of shipping, totalling at 45% of all seaborne trade and dominating the bulk shipping market. Energy trade consists of traded commodities such as crude oil, oil products, liquefied natural gas (LNG) and coal.

Metal industry trade

Shipping related to metal industry makes up for 25% of sea trade. It consists of raw materials and products of the steel and non-ferrous metal industries; iron ore, metallurgical grade coal, non-ferrous metal ores, steel products and scrap.

Agricultural trade

Agricultural trades include commodities, products and raw materials that are shipped for the needs of the agricultural industry. These include wheat, barley, animal feedstuffs, sugar, molasses, refrigerated food, fertilizers, oils and fats. Agricultural trade accounts for 13% of sea trade.

Forest products trade

Forest products are the industrial materials used for the manufacture of paper and paper board, and materials for the construction industry, such as timber, logs and lumber, wood pulp, plywood, paper and other wood products. Forest products trade makes up for 5% of sea trade.

Other industrial materials

Other industrial materials include commodities like cement, salt, gypsum, mineral sands, asbestos and chemicals among others. These account for 9% of sea trade.

Other manufactures

Other manufactures such as textiles, machinery, capital goods, vehicles, etc. total about 3% of sea trade in mass, but as for the monetary value the manufacture shipping accounts at somewhere around 50% of the sea trade in total. This is because manufactures are often of a high value. This part of sea trade has earned the saying “the mainstay of the liner trades”.

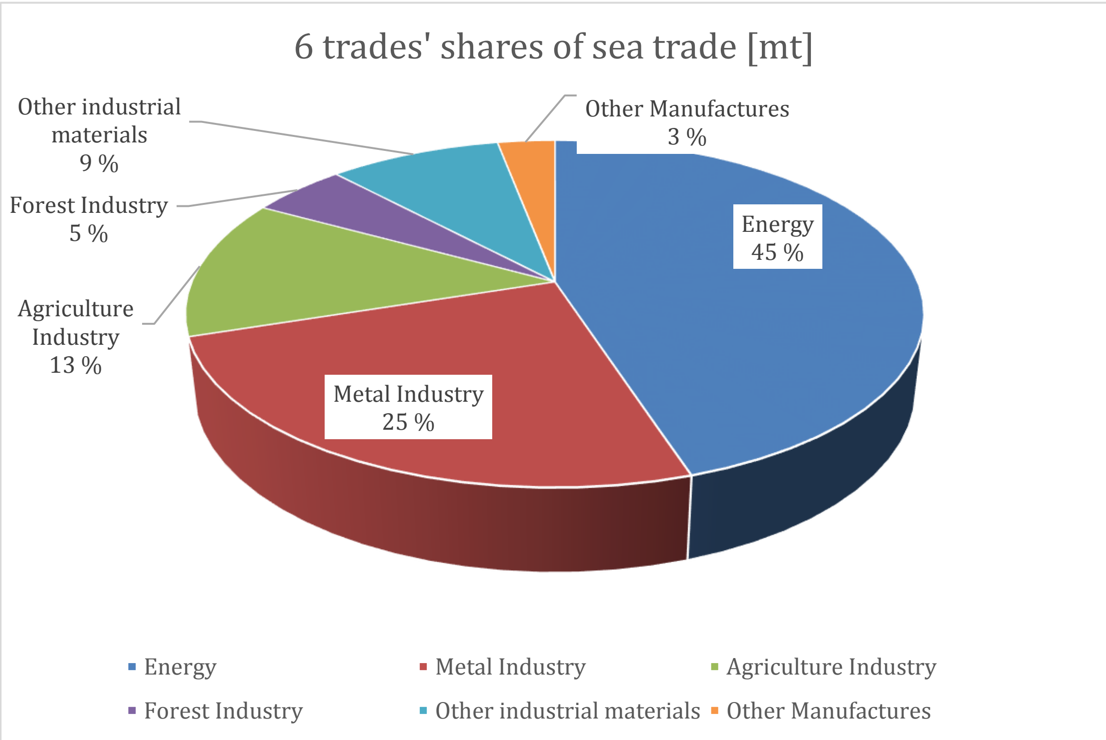


Figure 2.1 The shares of different trades of global sea trade by volume. (4)

2.3 DEMAND FOR SHIPPING

Shipping is considered to be based on what the economists call *derived demand* meaning that the shipping does not exist for its own sake, but to provide means for other industries to transport raw material commodities and manufactured goods from production sites to customers. One exception to this is the cruise industry, which does not have the purpose of transporting anything but acts as a service as such.

The Table 2.1 shows the key set of variables having effect on the demand and supply of shipping services. From these the most important ones are the current and expected state of world economy on demand side, and the size, composition and location of world fleet on the supply side. As the world economy is growing, there is an increasing need for transportation, which drives also the growth of world fleet by increasing the number of newbuilds being ordered and reducing the amount of ships scrapped. The other factors such as political events can have dramatic effects. As an example the restlessness in oil production areas have caused huge fluctuations in crude oil price, which is clearly visible later in this study, also.

Table 2.1 The key variables affecting the demand and supply for sea transport services.

Demand	*Supply*
The world economy	World fleet
Seaborne commodity trades	Fleet productivity
Average haul	Shipbuilding production
Political events	Scrapping and losses
Transport costs	Freight rates

From a customer's perspective the demand for shipping is a service. Following is listed the four main factors for the shipping service, that the customers are considering the most.

Price

The freight rate is always important. But as it is in the case of oil trade, that the proportion of the transportation cost has reduced from 49% in the 1950's to a mere 2.5% of the 1990's making the transportation cost less and less important for the oil companies.

As the cost of transportation has become so low in relation to the value of the cargo, especially in the case of crude oil, it has become a common practice to use crude oil as a speculative investment and also to use crude oil carriers as storages over low market times.

Speed

As inventory costs are incurred by the time in transit, shippers may have high preference for speedy delivery – depending on the value of the goods being transported. This is more important on the general cargo trades, where the parcels are of high value, than on the bulk shipping sector.

Reliability

As the inventory costs grow in importance both at sea and on land, the reliability and the guarantee for agreed transportation schedules to hold are many times worth more than the cheapest price for the shipper.

Security

Although shipments are insured against damage or loss during the voyage, many shippers are ready to pay extra for a security that they do not have to do that extra work that is incurred by the insurance claims.

The demand for shipping business is not simple to assess or predict, as the supply and demand mechanics of other industries around the world dictate the demand for transportation services, thus making the demand forecasting of marine transportation complex and difficult. This has also the consequence of shipping industry following the world economy's boom-bust cycles with significant delay and sometimes amplifying effects. (4) (11)

2.4 World Fleet

The world fleet is used to describe all ships in operation in the world, but for the purpose of this study the term is limited to include only the merchant vessels. UNCTAD reports the statistics of world fleet with following criteria:

"The figures cover seagoing propelled merchant ships of 100 gross tons and above, excluding

- inland waterway vessels,
- fishing vessels (from 2011 onwards only),
- military vessels,
- yachts,
- and offshore static and mobile platforms and barges (with the exception of FPSO - floating production, storage and offloading vessels - and drillships). (12)

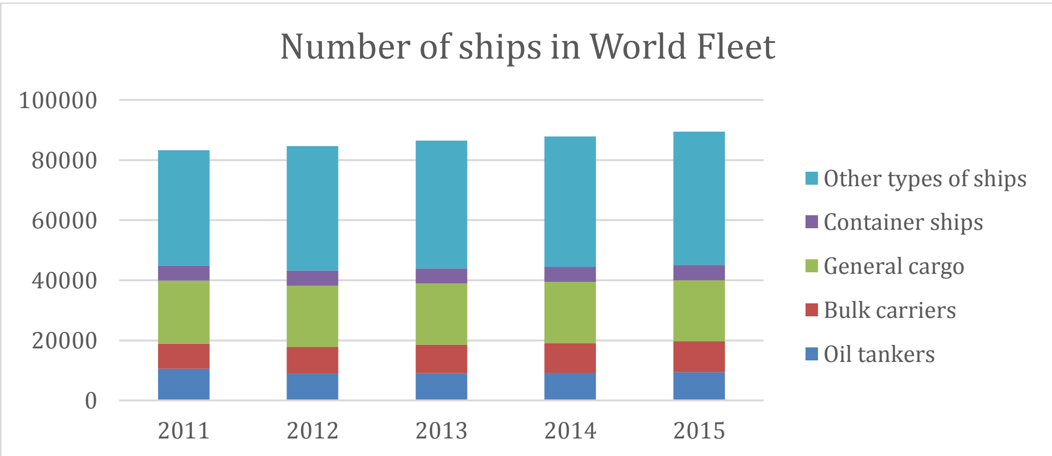


Figure 2.2 The number of ships over 100 GT, excluding inland, fishing and navy vessels, static offshore platforms and yachts. (12)

As can be seen from the number of ships in Figure 2.2, the division between the number of ships differs greatly from the deadweight capacity of the World Fleet seen in Figure 2.3. This shows how only relatively small number of huge bulker carriers and oil tankers carry overall the major part of the deadweight capacity of all ships. The Figure 2.3 also illustrates the trend of general cargo being carried by general cargo vessels being replaced by container vessels.

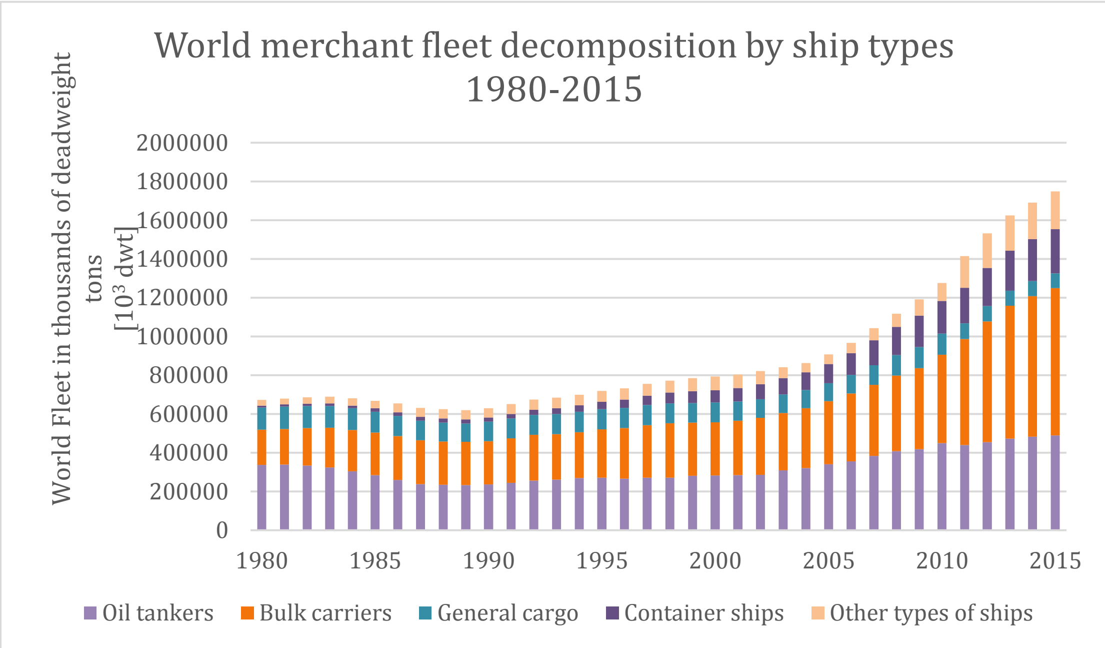


Figure 2.3 World merchant fleet decomposition by ship type. (12)

As of the beginning of 2015, 72% of world merchant fleet capacity was on either bulk carriers or oil tankers, as shown in Figure 2.4, which shows the shear scale of the bulk shipping industry in relation to other areas of shipping. (12)

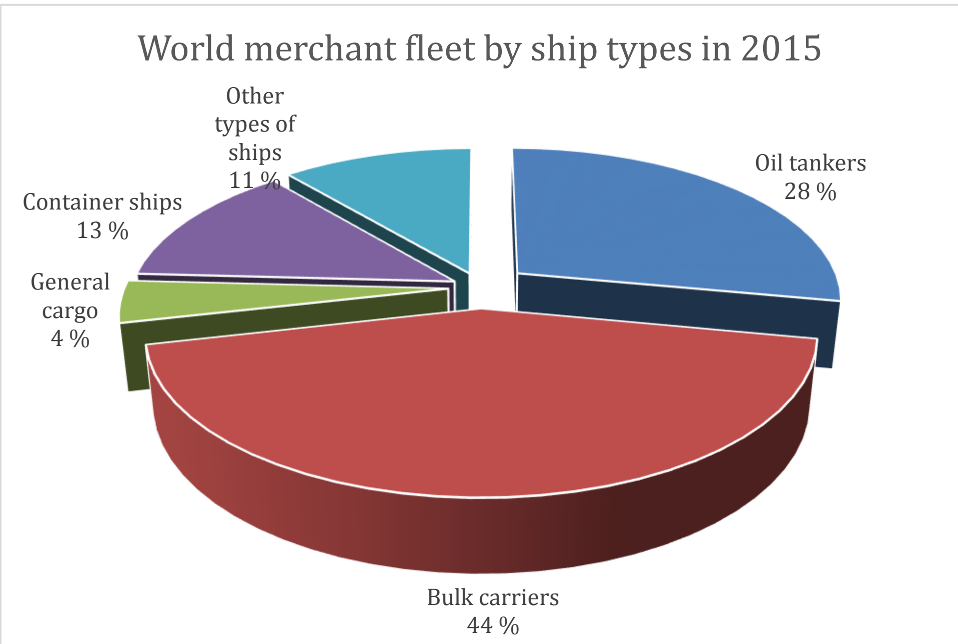


Figure 2.4 World merchant fleet decomposition by ship type in 2015. (12)

2.5 BULK, TRAMP, LINER AND INDUSTRIAL SHIPPING

There are multiple ways of categorizing shipping industry. The main division was already done according to the type of cargo, as described briefly in 2.1, and whether a parcel size is ship-sized or not. This gives us two main cargo flows:

- Bulk cargo; unpackaged cargo carried in ship-sized parcels: one ship – one cargo, and
- General cargo; packaged cargo carried in small quantities: one ship – many cargos.

Whereas the bulk cargo is mainly raw materials with low unit cost, the general cargo is typically more processed products with high unit cost. This is illustrated with the shipping cost function in the Figure 2.5, where raw material with low unit cost, such as oil, iron ore, coal and grain and low and far right with low degree of value added, whereas the machinery, electrical goods and wine are in the far left with rapidly rising unit cost. General rule of thumb is that the low unit cost cargos are carried in bulk and high unit cost cargos as a general cargo. (4)

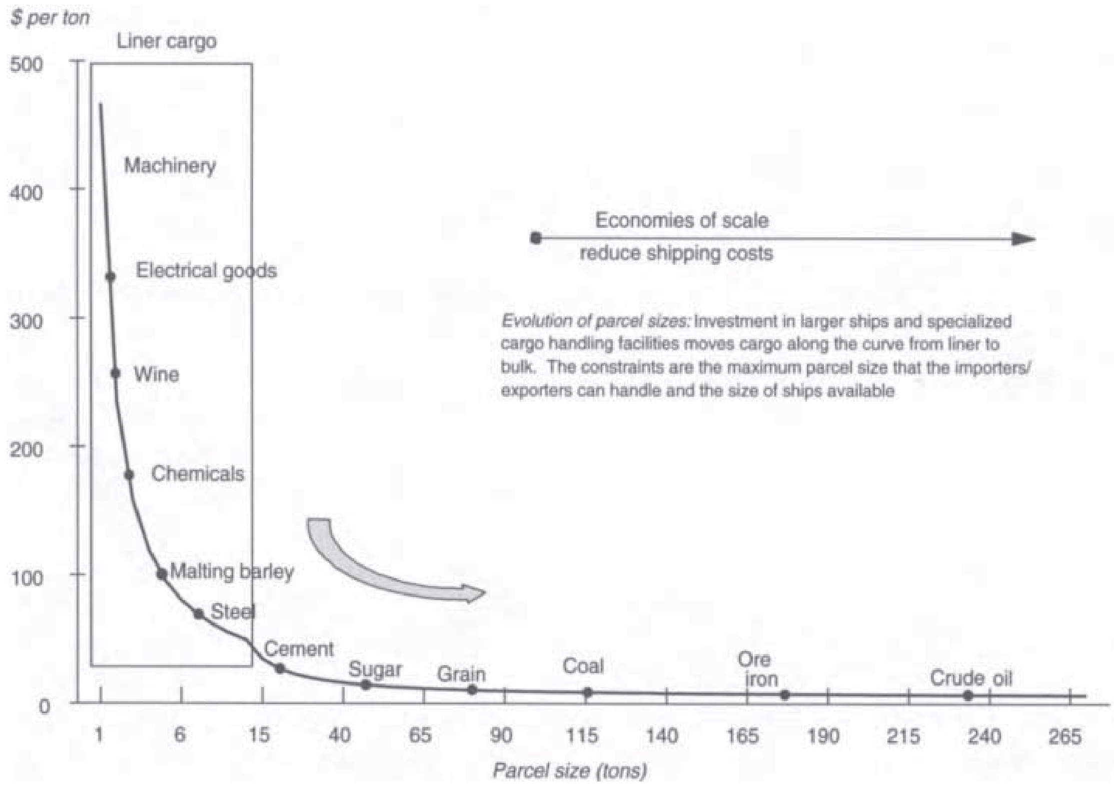


Figure 2.5 Shipping Cost Function. Note, parcel size should be thousand tons [10^3 tons]. (4)

The division between bulk and general cargo relates in most cases straight to the business logic, where the division is done between tramp and liner shipping, while the industrial shipping is somewhere in the middle:

- *Liner shipping* – ships are sailing on advertised routes and schedules;
- *Industrial shipping* – ships are sailing on a longer-term contract for a certain company;
- *Tramp shipping* – ships are sailing whenever and wherever they get employed on an ad hoc –basis.

Most of the liner shipping today is unitized general cargo carried mostly in standardised containers, whereas tramp shipping is mostly bulk cargo. Industrial shipping is a third category in between, as it is usually relatively regular but cargos are typically quite homogenous – combining characteristics from both liner and tramp shipping depending heavily of the customer company and its transportation needs. Figure 2.6 illustrates the different roles of bulk, industrial and liner shipping in the international transport system.

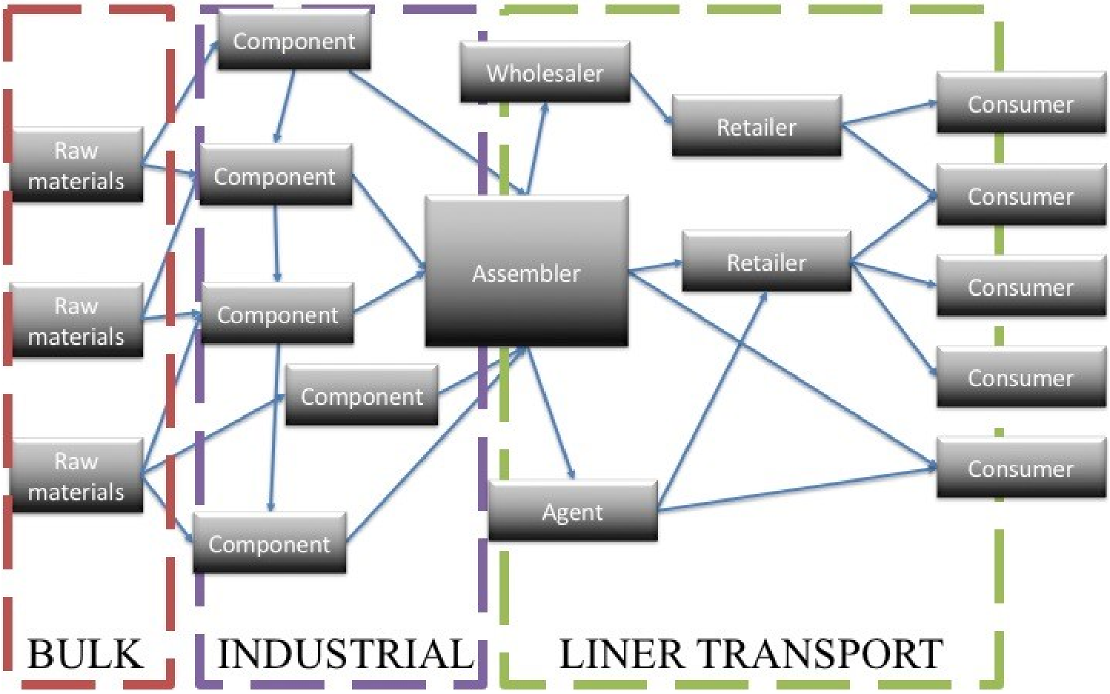


Figure 2.6 The international transport system, showing bulk, industrial and liner shipping sectors. Redrawn. (4)

For this work, the bulk shipping in the contexts of tramp and industrial shipping are in the focus.

2.6 TRAMP SHIPPING

"Without international trade, there would be no reason for the tramp [shipping] to exist." (6)

Tramp is a derivative from old from Middle English verb *trampen*, "to walk heavily", from circa 1388. The meaning attached to ships is from around 1880, while the more common use for "promiscuous woman" is as late as from 1922. There are many definitions to be found e.g. online, such as "any ship which does not have a static schedule or published ports of call" (13) and "steamship which takes cargo wherever it can be traded" (14). In this context it is not purposeful to go deeper into etymology.

More detailed definition for *tramp shipping* can be found, for example, in the since repealed EU competitive regulation (15): *"the transport of goods in bulk or in break-bulk in a vessel chartered wholly or partly to one or more shippers on the basis of a voyage or time charter or any other form of contract for non-regularly scheduled or non-advertised sailings where the freight rates are freely negotiated case by case in accordance with the conditions of supply and demand"*.

Tramp shipping – contrary to liner shipping – is not operated on scheduled or previously advertised routes, but rather as a function of supply and demand – mostly on a very global market. Tramp shipping markets are highly complex, as the demand for tramp shipping services are driven by multitude of factors closely connected to markets for raw materials, semi-refined products and finished goods and demand fluctuations in these. Some of these fluctuations are explained by the seasonal variations in production and consumption, while some are driven by geo-political and other reasons.

2.7 THE PERFECTLY COMPETITIVE MARKET

Shipping is also referred to as having conditions close to perfect competition. Perfectly competitive market is a term used in economic theory to describe markets, where there are

a) large number of buyers and sellers (for identical products),
b) perfect information; prices and world fleet composition,
c) no or low barriers of entry and exit,
d) existing companies have no advantage over new ones. (16)

Generally shipping fulfils these requirements well. As ships are mobile assets, the shipowners (suppliers) are able to react to the fluctuations of demand by moving their ships to almost anywhere in the world, where demand for transportation services emerges. This fulfils the first criteria, as almost any shipowner can offer their services almost anywhere in the world.

Today, anybody with the access to internet, has also an access to not only the composition and position of the world fleet at any given time – thanks to systems such as Automatic Identification system (AIS) – but also to the order books, as they are mostly public. As the pricing information is made available daily by number of parties, such as brokers, there is also close-to-perfect information available for both established and new players in the market, fulfilling the second criteria.

There is very low entry or exit barriers in shipping, as basically anyone can buy a ship, given that they have access to sufficient capital, and start carrying cargo with next to none previous knowledge, as almost all parts of the daily operations can be outsourced, if one’s own background does not support such activities. This does not mean it would be profitable, but in this context it is a valid point.

As shipping is described an industry of high risk – low return, meaning that there are a lot of risk involved as markets are volatile, there is no clear gain for existing companies over new ones. Of course industry veterans have faced difficult times previously, but as of today no one has managed to come up with even remotely reliable system of predicting the future market booms and busts, there is only so much what an experience can offer for an old player, as the global markets hit everyone at the same, unpredictable way. (4)

2.8 SHIPPING CONTRACTS

Relevant shipping contracts can be divided into two main categories in the context of this work: *Bills of Lading* and *Charter Parties*.

> *Bill of Lading* is the contract between a shipper and a carrier and it is tied to a certain vessel and cargo. It serves mainly as a receipt for loaded cargo, but also as a title and as an evidence of contract of carriage. (17)

C*harter parties* are the contract between the carrier and the shipper establishing the ground rules for the transaction. They vary greatly from a single *voyage charter* to time charters or bareboat charters that can span for up to 15 to 20 years.

Voyage charter

> The voyage charter is the simplest of the charter parties. It is an agreement for the use of ship between loading and discharging ports. A cargo owner, who has a transport need will contact a shipowner – usually via brokers – to find an available shipowner with an available, suitable and seaworthy ship for the cargo to be transported for a single voyage. The shipment is of specific quantity of specific cargo, from specified load port to specified discharge port – with the possibility of multiple ports in each end.
>
> Typically, the terms of contract are strict and the charterer usually pays freight rate per-ton-basis of goods or commodities carried.

Contract of Affreightment

> Contracts of Affreightment (CoA) are an attractive choice for ship owners to pursue, as they usually provide employment for the fleet over a considerably long period. In theory, CoA is in principal a single contract made for multiple voyage charters. Typically, the contract is for a certain period, certain amount of cargo or for recurrent, i.e. monthly carriage. The rate is set according to tons carried or deliveries. Usually a specific vessel is not assigned to CoA, contrary to voyage charters. Contracts of affreightment are common in industrial shipping.

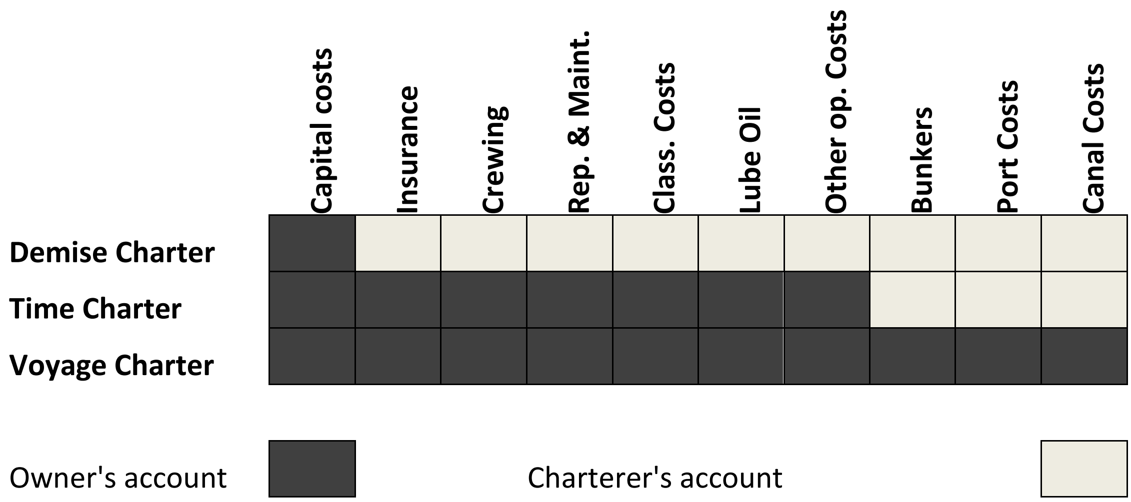
Time charter

> Unlike in the case of voyage charter or CoA, the charterer takes the operational control of the ship when time charter is agreed upon. Charterer is also responsible for arranging insurance and paying hire to the owner. The rate paid by the charterer is agreed by charter time.

Demise charter

> Demise charter, known also as bareboat charter, is not too common nowadays. It is usually used as an alternative way of financing a vessel or for the purpose of tax arrangements. Typically demise charter has very long charter period and the charterer is responsible for the full control of the ship.
>
> The differences between the aforementioned charter types and relevant cost responsibilities are summarised in Table 2.2, as illustrated by Fearnley Consultants. (6)

Table 2.2 Cost elements in demise charter, time charter and voyage charter. Redrawn. (6)



Other charter types

The requirement contract is a contract type, which allows the customer to call for transportation service to be performed under contract of carriage when the customer needs it during the contract period, thus differing from CoA. Typically, the requirement contract is used between one customer and one service supplier to meet all the customer's transportation needs. It is mostly used in car trade. (6)

The cross-space charter is typically a characteristic of liner shipping, but is met in the tramp shipping in Pure Car Carrier (PCC) and chemical tanker markets in some instances. The cross-space charter is an agreement, under which competing shipowners or operators supply some capacity to each other, if available. The agreement can be relatively informal and short-term for one voyage or for a longer period of time, in which case more formal agreement with similar terms to CoA is agreed upon. (6)

Co-service agreement is used when no single service provider has enough capacity to fulfil the customer's transportation needs, and the customer has no preference of carrier. Most commonly co-service agreements are entered between the carriers to bid together for the contract, but similar outcome can be achieved if one carrier enters a contract with the customer and sub-contracts some of the service to other carriers. This is mainly seen in chemical tanker market. (6)

2.9 PLAYERS IN THE SHIPPING MARKET

There are many different types and sizes of players operating in the shipping market. From an individual *sole trader* to huge liner-shipping consortia, there are all kinds of business models and co-operation schemes present, some of which are overlapping in many occasions. Figure 2.7 illustrates in a simplified manner the use of different terms and their relationship to each other. Noteworthy is the position of a shipping pool, and how the cargo flows are not directed to specific ship owner inside the shipping pool. Pools are discussed more in designated chapter 4, Shipping Pools.

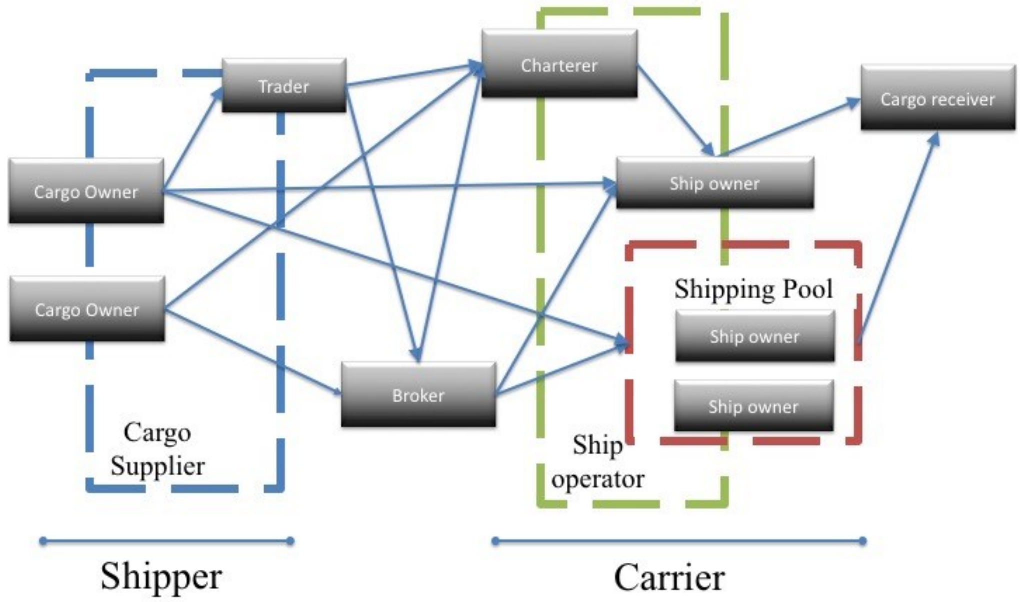


Figure 2.7 Simplified illustration of players acting in the shipping market.

Cargo owner

Everything starts with a cargo owner or supplier in the shipping business. Without a cargo, there is no need for shipping services with the aforementioned exception of cruise business. Cargo owner is typically a mining company, oil major or a manufacturer of goods of some kind with a need for transportation. In today's market the cargo owner typically does not want to bear the responsibilities of owning their own fleet, but instead prefer to buy the transportation as a service from a company specialized in shipping.

Trader

Trader is an individual or a small undertaking of some sort who buys and sells cargos without ever seeing it. Trader relies on his insight and algorithms in order to time their buying and selling actions in order to make a profit in the process. Sometimes trading is called second-business, as it describes the hectic character of business where tens of thousands are made or lost in a second. Traders rarely add any real value in the shipping business value chain.

Shipper

Shipper is the person or company who is the supplier or owner of the cargo being shipped, also known as *consignor*. (17)

Carrier

Carrier is a person or entity who performs or procures the performance of carriage of cargo. (17)

Charterer

A charterer is an entity arranging the carriage of cargo by ship or the hire of a ship. Charterer may or may not be a cargo-owner or shipper also.

Shipowner

Shipowner is the company or other entity who owns the ship, hence the name. Shipowner may or may not be actually operating the ship.

Ship operator

A ship operator is the company or entity responsible for the operation of the ship, that may or may not own the ship. Dedicated ship operating companies exist, that do not own some or any of the ships they operate.

Carrier

Carrier undertakes the transport of goods from one point to another, and it may or may not be the same as the operator or charterer.

Broker

Broker is an individual or a party used to communicate between ship owners and shippers to find employment for the ships and find ships for the cargoes. Even in today's IT-driven world human brokers play vital role connecting the suppliers and buyers of different parts of shipping services, as even today, personal connections are highly valued.

Other players exist, such as receiver of cargo, seller of cargo, buyer of cargo and shipping forwarders to name a few.

2.10 Bulk shipping

Bulk shipping is transportation of unpackaged goods in large quantities in order to minimise the transportation costs per unit, as the cargo itself has typically low unit value. Most of the bulk shipping cargo is raw materials such as oil, iron ore, coal and grain. Bulk cargos are divided into four main categories: major and minor dry bulks, liquid bulks and neo-bulk cargoes. These are discussed more in the following sub-chapters. Bulk tonnage makes up two thirds of the world merchant fleet, as discussed in chapter 2.4, World fleet.

Bulk shipping dates back to at least two thousand years ago, when Rome shipped grain from northern Africa, Sicily and Egypt with purpose-built grain vessels. Other examples of bulk shipping in the history are the infamous eighteenth century slave ships as well as the Dutch tea clippers and the colliers of the nineteen century.

The modern era of bulk shipping started with the English coal trade in the seventeenth century, but grew to became the major part of shipping only after the Second World War, as the large fleets of specialized crude oil tankers emerged to serve the post-war economies in Western Europe and Japan. (4)

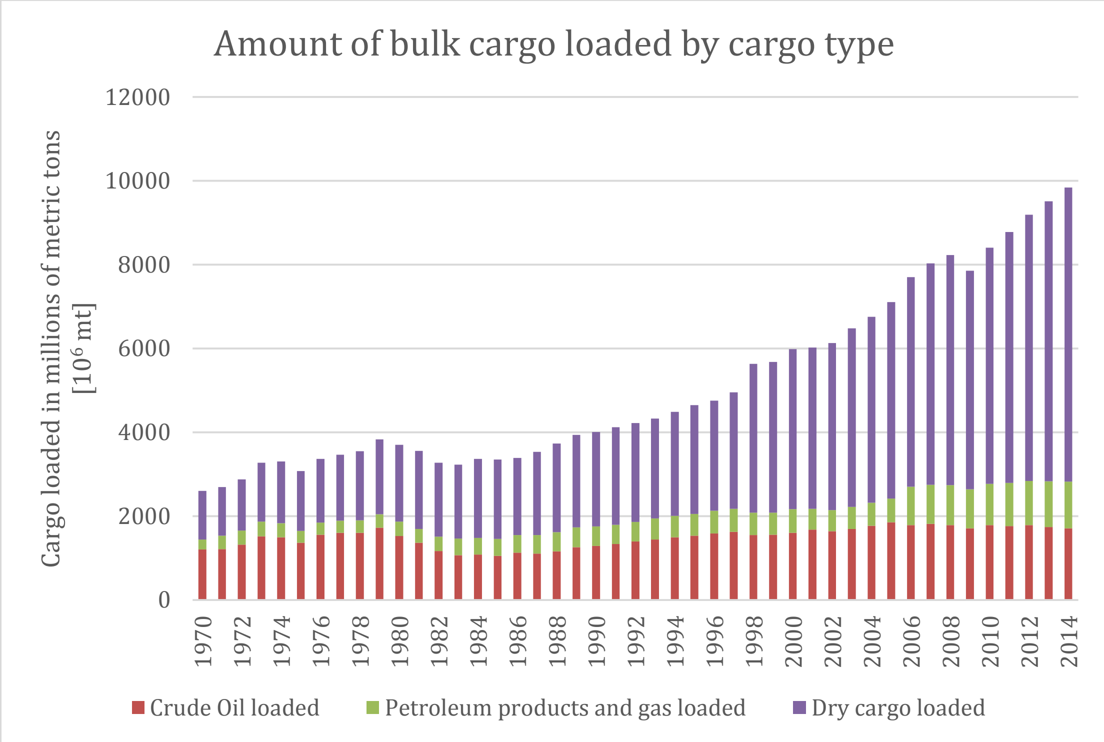


Figure 2.8 Bulk shipping cargo volumes between 1970-2015. (12)

Figure 2.8 presents the amount of cargos loaded annually worldwide by three types: *crude oil, dry cargo, petroleum products* and *gas*. As the figure shows, there has been a strong growing trend after the volatile years of the seventies. The other notion to be made is that while the crude oil volumes have been quite stable, the products and gas has grown rapidly during the 00's mainly due to the rapidly grown demand of LNG. The main part of the global growth has come from the dry cargo sector.

2.10.1 Dry bulks – The backbone of international trade

Dry bulks are homogenous cargoes – granular or lumpy in composition – that can be transported with dry bulk vessels and handled with automated grabs and conveyers. Iron ore, coal, grain, bauxite and phosphate rock are by far the most transported dry bulk commodities, thus called the five major bulks.

Iron ore

Iron ore is the single largest traded bulk commodity within this group, totalling 1,5 billion tons moved by ships in 2011. The majority of iron ore goes from South America and Australia to Far East, especially China.

Coal

Coal is still very important commodity worldwide. It is used to produce some 40% of world's total electricity. The major trade routes are from North America, Argentina, Australia and South Africa to Far East and Europe.

Grain

The total amount of grain traded annually is 350 million tons. Most of the grain trade is from North America, Argentina and Australia to all over the world.

Bauxite

Bauxite is the raw material for aluminium. Australia, China and Brazil are the three biggest producers of bauxite, while China, Russia and Canada are the biggest producers of aluminium.

Phosphates

Phosphates are used to make fertilizer, which are needed in agriculture. 75 percent of phosphate rock exporters are located in the Middle East and North Africa. Imports are relatively evenly spread across the countries in Europe, Asia and North America, with the exception of India, which is the largest importer accounting for roughly quarter of world total. (18)

Minor dry bulks

Minor dry bulks contain all the other dry bulks that are not included in the five major bulks. Among these the most important ones are steel and forest products, minerals, fertilizers, building materials, manufacturer goods, cement, salt and other chemicals.

2.10.2 Liquid bulks

Liquid bulks are considered as all cargo that is free-flowing and are stowed in a tanker's holds, to and from which they are pumped or sucked. Liquid bulk trade consists that of crude oils, oil products and liquid chemicals. Also caustic soda, vegetable oils, wine and juice are transported using tankers to name a few.

Crude oil

Crude oil is the single most important commodity traded in the world today. In 2013 the total volume of crude oil shipments averaged 1.8 billion tons. The major crude oil trade routes go from areas located in Western Asia, Africa, developing America and the transition economies to Japan, North America, Europe and developing Asia. (3)

Oil products

Oil products, also known as petroleum products, are a group of materials that are derived from crude oil in oil refineries. The output products range from different grades of fuel oils and gasoline, diesel oil, asphalt, tar and lubricating oils to name a few. In 2013 over 1895 million tons of oil products were carried by sea.

2.10.3 Neo-bulk

Neo-bulk is relatively new addition to the bulk shipping family as a definition. It is used to describe all the other, non-free flowing homogenous bulk that is not covered by dry or liquid bulk, such as steel products, cars and containers. These are not in the scope of this study.

2.11 SHIPS IN BULK SHIPPING MARKET

Tramp shipping market is fragmented into 11 sub-markets, each of which varies between 1000 and 5500 ships. The exception for this is LNG market, that consists of fewer than 200 ships, but is rapidly rising due to the US shale gas boom and Arctic gas drilling operations. Average shipowner companies in bulk shipping are relatively small – owning only 2-6 ships. The largest companies in each segment account for 4-5% of the market. In comparison on the buyer's side, the shippers are often very large international companies or trading houses with significant amount of buying and bargaining power.

The categorization of ships by their deadweight tonnage is an industry-standard way of give a rough category for the size and capacity of the ship. The categories are based on dimensions-restricted waterways, mainly Panama Canal locks, and draft and height limitation of Suez Canal. The categories for dry and liquid cargo vessels with related size restrictions are listed in Table 2.3.

Table 2.3 The most relevant ship size categories and their respective limits and typical tonnages.

Cargo		x 1 000 dwt	Draft [m]	Length [m]	Beam [m]
Dry	*Small Handysize*	*28*	–	–	–
	Seawaymax	*28*	*8*	*226*	*24*
	Handy	*28-40*	–	–	–
	Handymax	*40-50*	–	*190*	–
	Supramax	*50-60*	–	–	–
	Panamax	*52*	*12,5*	*304*	*32,6*
	New Panamax	*120*	*18,3*	*427*	*55*
	Capesize	*>120*	–	–	–
	Chinamax	*380-400*	*24*	*360*	*65*
Liquid	*Aframax*	*75-115*	–	–	–
	Suezmax	*160*	*20*	–	–
	VLCC	*150-320*	–	–	–
	Malaccamax	*300*	*20,5*	*330*	*60*
	ULCC	*320-550*	–	–	–

Handysize

The handysize is the smallest definite ship size category. Handysize vessels are mainly dry bulk and product tankers serving mostly on regional trade routes, as they are capable of entering smaller ports than their larger, more economical counterparts. Handysize is the largest vessel class by number with some 2000 vessels worldwide, most of which are build in Asia. Handysize class can be divided into three sub-categories:

a) Handy < 40 000 dwt,
b) Handymax 40 000 to 50 000 dwt, and
c) Supramax 50 000 to 60 000 dwt.

Panamax up to 50 000 dwt

The Panama Canal was opened in 1914 and the dimension restrictions for the shortcut between the Atlantic and Pacific has been the same ever since: 50 000 dwt for a loaded or up to 80 000 dwt for an empty vessel.

New Panamax up to 120 000 dwt

The Panama Canal expansion project is due to be completed and the new locks operational in 2016. This raises the maximum dimensions of the through passing vessel up to 120 000 dwt.

Capesize – above 120 000 dwt

Capesize is the largest vessel class – name stemming from the fact that the vessels are too large for the Panama or Suez Canal, hence the name after Cape Horn and Cape of Good Hope. Traditionally this category has been meaning vessels above 100 000 dwt, but since the expansion of Panama Canal is due to allow vessels up to 120 000 dwt to pass through, it is only natural that Capesize follows that definition, as it is – by definition – for vessels too large to transit *the* canals.

Other categories also exist. Table 2.4 below shows the two commonly used tanker-specific categorisations, the *Average Freight Rate Assessment (AFRA)* and the *flexible market scale*.

Table 2.4 Average freight rate assessment (AFRA) and flexible market scale size tanker size comparison.

Class (AFRA)	*Size in 1000 DWT*	*Class (Flex. Market scale)*	*Size in 1000 DWT*
General Purpose Tanker	10 - 25	*Product tanker*	10 - 60
Medium Range tanker	25 - 45	*Panamax*	60 - 80
LR1 (Large Range 1)	45 - 80	*Aframax*	80 - 120
LR2 (Large Range 2)	80 - 160	*Suezmax*	120 - 200
VLCC (Very Large Crude Carrier	160 - 320	*VLCC*	200 - 320
ULCC (Ultra Large Crude Carrier	320 - 550	*ULCC*	320 – 550

The distribution of large tankers, as seen in Figure 2.9, shows how most of the world's tanker fleet consists of ships of around 300 000 dwt, with only few being significantly larger or smaller.

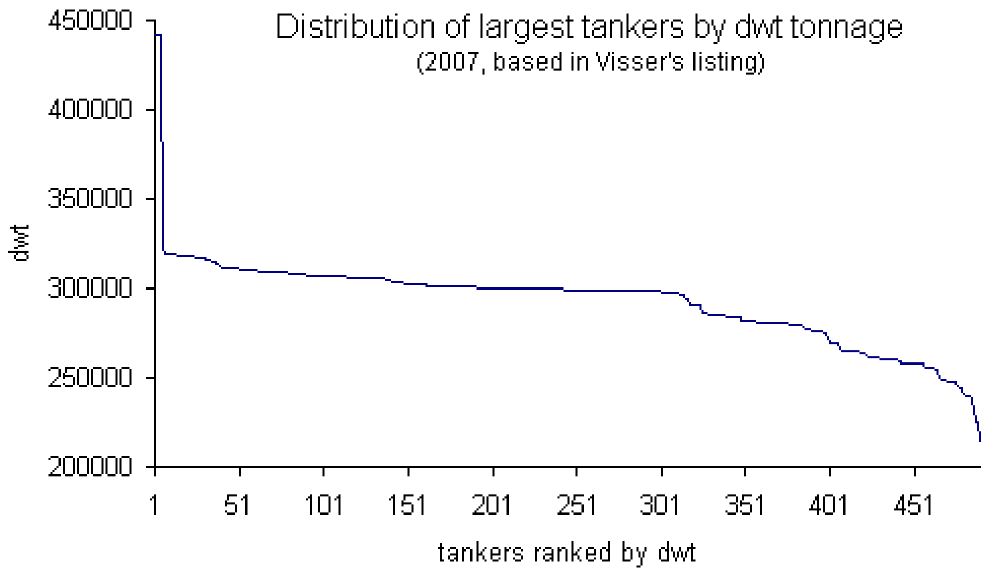


Figure 2.9 Largest tankers by dwt tonnage and count. (19)

2.12 WorldScale

The *WorldScale* is a freight rate index used in the tanker market as a convenient way to negotiate freight rates per barrel of oil on different trade routes. It was introduced during the Second World War on a schedule published by the British Government as" a basis for paying the owners of requisitioned tankers". The schedule indicated the cost of transporting a ton of cargo on a specific route.

The WorldScale is annually revised and published in a book by WorldScale Panel. The calculation of WorldScale is based on a cost structure of a standard tanker of 75 000 dwt, as shown in Table 2.5 below. It is used to calculate freight rates for ton of cargo basis, and the freight are negotiated as a fraction of WorldScale, WS100. For example WS75 indicates freight rate of 75% of listed WorldScale rate on that specific route. (20)

Table 2.5 WorldScale basis tanker. (20)

Total Capacity	*75 000 tonnes*
Average service speed	*14,5 knots*
Bunker consumption:	
Steaming	*55 tonnes per day*
Other	*100 tonnes per day*
In port	*5 tonnes per port*
Grade of fuel oil	*380 cst*
Port time	*4 days for a voyage from one loading port to another discharging port*
Static hire element	*$ 12 000 per day*
Bunker price	*$ 614,81 per tonne*
Port costs	*Most recent available*
Canal transit time	*30 hours per Suez transit*

3 SHIPOWNER ECONOMICS AND ENERGY EFFICIENCY

This chapter describes the relevant parts of shipowner economies and energy efficiency legislation at IMO level.

3.1 SHIPOWNER ECONOMICS IN BRIEF

Shipowners have two main areas of business available, the freight market and the so-called asset play. The first is the primary way of earning in the sense that transportation of goods is the purpose for shipping companies to exist in the first place. Paradoxically, the profit margins of freight market have been low and highly volatile throughout the history. This is why on large parts of the shipping industry any major profits are made with the asset play. As in any area of business, shipowners seek to maximize their return on investment (ROI), calculated with the equation 3.1 below.

$$ROI = \frac{(R_1 - DP_1) + (MV_1 - MV_0)}{MV_0} = \frac{Trading\ Profit + Asset\ Play}{Value\ of\ Fleet} \qquad 3.1$$

where
R = trading cash receipts during investment period,
DP = depreciation of the vessel(s),
MV = market value of the fleet of ships. (4)

Ship owner revenue and cost structure can be seen in Figure 3.1, where the owner's cash flow chart is illustrated, according to Stopford (4). Noteworthy is multitude of aspects that need to be taken care of.

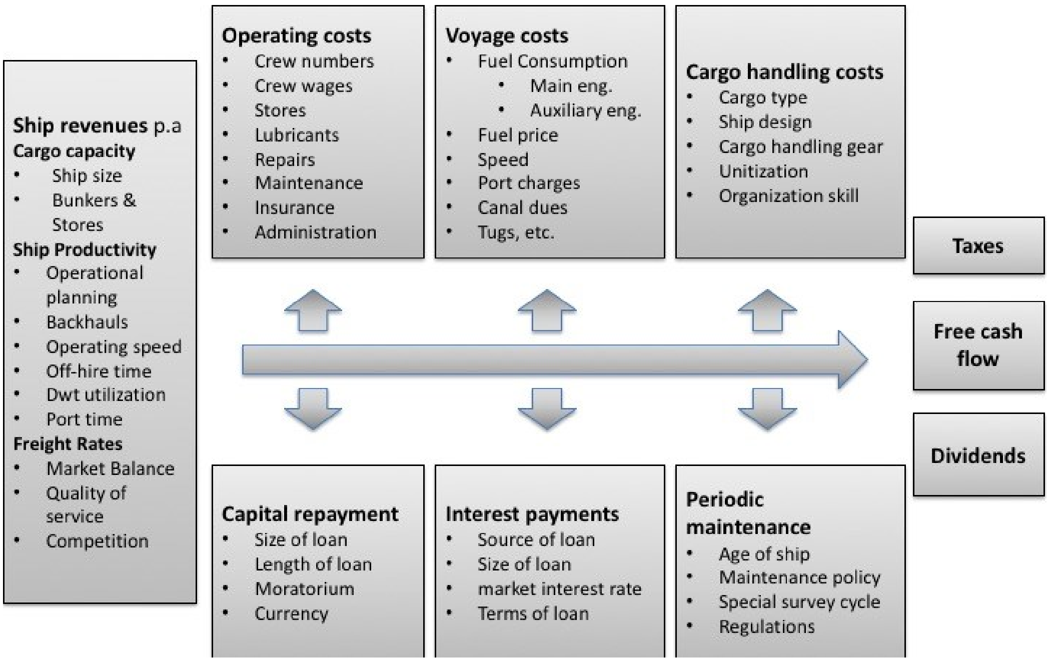


Figure 3.1 Shipowner cash flow model and factors affecting different parts of it. Redrawn. (4)

Shipping is high risk – low return business on average. Numerous shipping companies and banks financing their business have gone out of business – sometimes very quickly – when they have failed to account for the full risk of their investments. Shipowners – by definition – own ships, which means they need to buy, sell and charter them in and out according to current and expected capacity needs. Asset play means buying and selling ships regardless of own capacity needs in order to make money on the side by ordering newbuildings or buying second-hand ships when the market prices are low and selling when the markets are high. This is of course much easier said than done, as the newbuilds take usually a couple of years to enter the market and the cyclical nature of freight and ship markets are impossible to predict. (10)

3.2 ENERGY EFFICIENCY AND CARBON EMISSIONS IN SHIPPING

Energy efficiency and carbon intensity have been a very hot topic also in shipping, even though shipping is the most energy efficient form of transportation in regards of fuel burned for every ton of cargo carried over a distance, and great efforts are made by IMO, researchers and the shipping community to come up novel ways to reduce the emissions, carbon intensity and overall environmental impact of shipping, as many of these noble goals have straight correlation into fuel consumption and thus financial success.

Even so, there are huge differences between the individual ships when it comes to fuel efficiency. The oldest ships sailing at sea are over 20 years old, which means that also the propulsion technology is from the previous millennia. This means for example, that of the world container fleet the bottom 5% performers have 48% higher operational CO_2 intensity than the industry average. (21) As shown in Figure 3.2, the vast majority of carbon emissions from shipping is from oil tankers, bulk carriers and containerships. Admittedly, they do also carry majority of the seaborne cargo. (1) This combination makes them ideal focus group in order to find ways to cut down both fuel consumption and thus emissions, both of which help the shipowners financially, also.

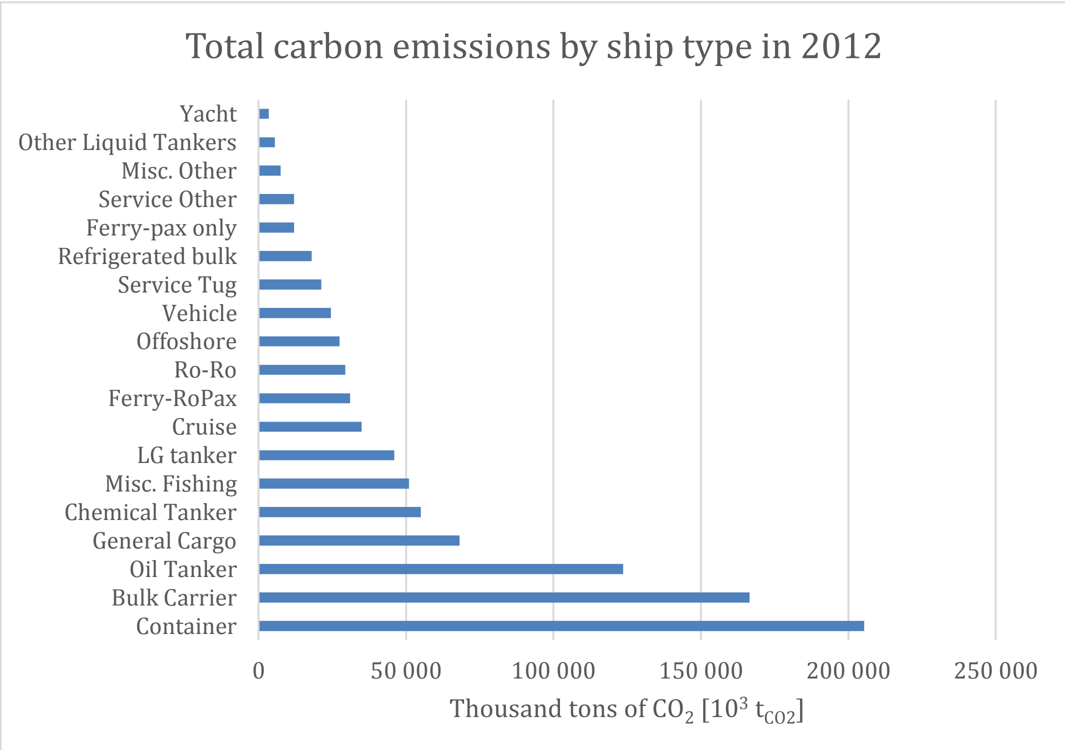


Figure 3.2 Total carbon emissions by ship type in 2012. (1; 16)

3.3 MARPOL AND THE HISTORY OF ENVIRONMENTAL CONCERNS AT IMO LEVEL

The International Convention for the Prevention of Pollution from Ships (MARPOL) is a convention developed by the IMO to prevent pollution of marine environment by ships – from both operational and accidental causes. It is based on the 1973 convention complemented by the 1978 Protocol, and came into force in 1983. (22)

Today the convention is signed by a total of 152 states covering 99.2% of world shipping fleet. The ships flagged under the signatory states are subject to its requirements at all times regardless of the sailing area.

MARPOL consist currently of six Annexes, shown in Table 3.1 below. Of these, the sixth one, *Prevention of air pollution from ships,* is in the scope of this work.

Table 3.1 The Annexes of MARPOL 73/78 Convention and their entries into force

Annex	*Title*	*Entry into Force*
Annex I	prevention of pollution by oil & oily water	2 October 1983
Annex II	Control of pollution by noxious liquid substances in bulk	6 April 1987
Annex III	Prevention of pollution by harmful substances carried by sea in packaged form	1 July 1992
Annex IV	Pollution by sewage from ships	27 September 2003
Annex V	Pollution by garbage from ships	31 December 1988
Annex VI	**Prevention of air pollution from ships**	**19 May 2005**

Annex VI – Prevention of Air Pollution from Ships

The Annex VI was first adopted in 1997. It set the limits on emissions from ships exhausts, e.g. sulphur oxide (SOx), nitrogen oxide (NOx) and volatile organic compounds (VOCs) and prohibits deliberate emission of ozone depleting substances, altogether. After coming into force in 2005, it was examined and revised. The revised Annex VI was adopted in 2008 and came into force in 2010.

The revised Annex VI main changes are a progressive reduction of global emissions of SO_X, NO_x and particulate matter, and the establishment of SOx Emission Control Areas (SECAs).

Another set of amendments to Annex VI were adopted in 2011 included the mandatory Energy Efficiency Design Index for new ships, and the Ship Energy Efficiency Management Plan for all all ships; abbreviated as EEDI and SEEMP, respectively. EEDI and SEEMP entered into force at the beginning of 2013. (22)

3.3.1 EEDI – Energy efficiency Index for newbuilds

EEDI is used to estimate the future scenarios of how the energy consumption is going to develop in the coming decades, as reported by a series of IMO GHG Studies.

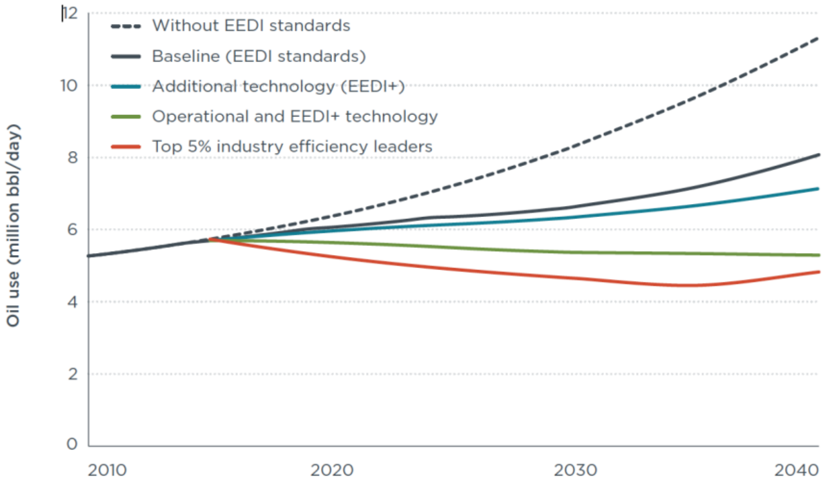


Figure 3.3 Global shipping fleet petroleum use with the new ship efficiency standards, additional technologies and operational measures, and deployment of industry-leading in-use efficiency measures. (21)

As can be seen from the Figure 3.3, there is an urgent demand to improve the shipping industries energy efficiency, and there is already a huge potential gains available with the technologies of today, as can be seen from the Figure 3.4, where the scatter of energy efficiencies of the world container fleet is illustrated.

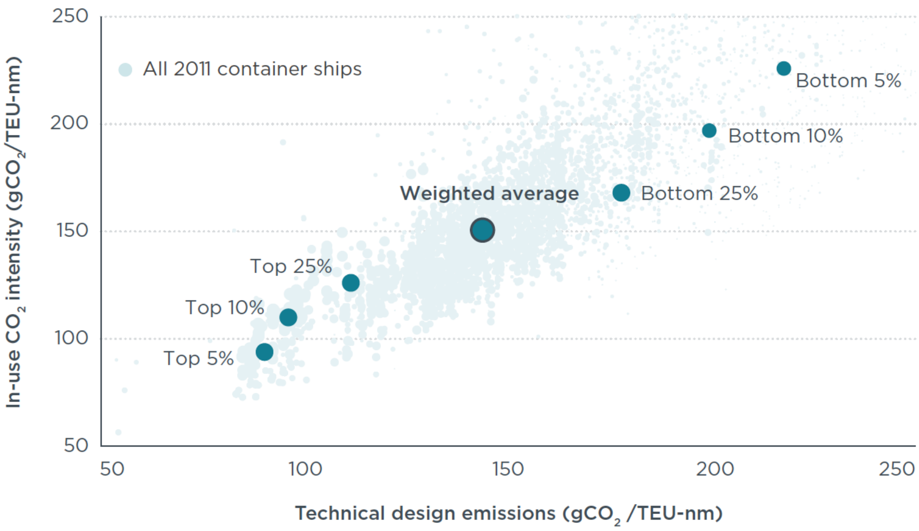


Figure 3.4 Technical and in-use CO2 emissions from 2011 containerships. (21)

As there is some controversy and ongoing discussion on the benefits and the applicability of EEDI as it is becoming extensively complicated with multitude of correction factors, and claims of giving mixed results in some cases, as shown by Delaney (23), the EEDI is excluded as too complicated and controversial metric to be used as a basis for the pool point calculation.

3.3.2 EEOI – Index for operational efficiency

In 2009, IMO published *Guidelines for voluntary use of the ship energy efficiency operational indicator (EEOI)*. EEOI is in its core a carbon intensity metric measuring the tons of carbon dioxide emitted for a ton of cargo carried over a nautical mile. This gives a simple and easy to understand metric to benchmark the operational energy efficiency of ships. The EEOI is calculated using the equations 3.2 and 3.3 for single voyage and for number of voyages, respectively.

$$EEOI = \frac{\sum_j FC_j * C_{Fj}}{m_{cargo} * D} \left[\frac{t_{CO_2}}{t_{cargo} * nm}\right] \quad 3.2$$

$$EEOI_{Average} = \frac{\sum_i \sum_j (FC_{ij} * C_{Fj})}{\sum_i (m_{cargo,i} * D_i)} \left[\frac{t_{CO_2}}{t_{cargo} * nm}\right] \quad 3.3$$

where:
i = the voyage number;
j = the fuel type;
FC_{ij} = the mass of consumed fuel j during a voyage i;
C_{Fj} = the fuel mass to CO_2 mass conversion factor for fuel j;
m_{cargo} = cargo carried (tonnes) or work done (number of TEU or passengers) or gross tonnes for passenger ships; and
D = the distance in nautical miles corresponding to the cargo carried or work done. *(24)*

While the EEOI is simple in its form, there have been some competing suggestions for the same purpose. Three main alternatives are listed with the main differences in respect to EEOI:

- EEJI is the Japanese proposal at IMO, where the main difference is the use of *dwt*nm* instead of *transport work*.
- US has proposed both the use of EEUSI, which uses *energy per time at sea* per unit of distance travelled, and the use of *Fuel Consumption per Distance*, latter of which is self-explanatory. (24)

Further studies of these alternatives are not in the scope of this study.

4 SHIPPING POOLS

Shipping pool is the primary form of horizontal co-operation between carriers operating in the tramp shipping and industrial shipping markets. Pool's primary objective is to find employment for pooled vessels on a sensible mixture of short-, medium- and longer-term-basis.

Pooling as a significant phenomenon originates in the aftermath of the tanker crisis of the early 1970's followed by the bulker crisis about a decade later. There are few definitions for a shipping pool in the scarce literature about the topic:

"A merchant shipping pool is a collection of similar vessel types under various ownerships placed under the care of an administration. This administration markets the vessels as a single, cohesive fleet unit and collects – 'pools' – their earnings which, in due course, are distributed to individual owners under pre-arranged 'weighting' system, by which each entered vessel should receive its fair share." (7)

"Shipping pools can be briefly described as vehicles that enable the marketing of transportation services of different owners through a single chartering entity, with the sharing of pooled income on a pre-agreed basis." (5)

As can be seen from these quite similar definitions, the incentive for pooling is to join efforts in order to gain more bargaining power and higher profitability, as shown in the Figure 4.1 about average pool earnings. The age of the dataset is noted, but it is still the most recent one available in the literature, and its validity was not questioned in the more recent, comprehensive study by Fearnley Consultants. (6)

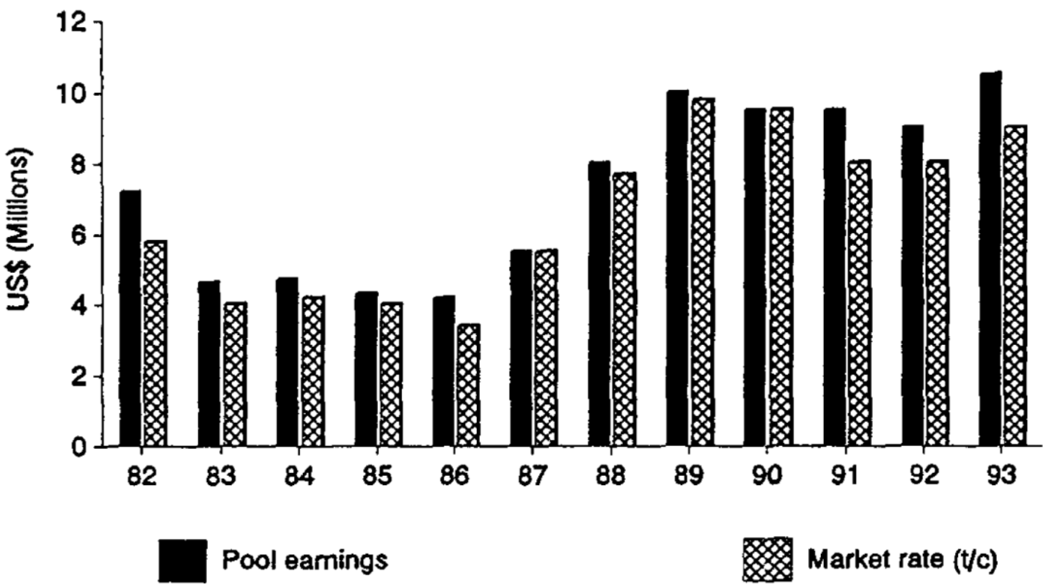


Figure 4.1 Average annual pool earnings compared to 12 months time charter earnings. (8)

4.1 MOTIVATION FOR POOLING

As it has been established, shipping markets can be and many times are unpredictable and harsh in behaviour, and shipowners do seek security for their future. One option to alleviate some of the burden of unpredictability is to co-operate with other shipowners and form a shipping pool.

The motivation for pooling stems from owners' willingness to stabilize income, share risk, and exploit massed resources and to be able to access contracts of affreightment. Enhanced bargaining power and higher profitability are identified as key drivers behind pooling, also. (5)

Owner's perspective

From owner's standpoint the motivation for pooling originates from the need to organize its commercial operations purposefully and to enhance efficiency. By pooling with other shipowners they are able to offer and provide meaningful transportation services and also to bid for contracts of affreightment, which would be unattainable for a single owner who still today typically has a fleet of 2 to 6 vessels in average. Pooling also enhances the bargaining power of the owners against charterers in negotiations, thus increasing profit margins and profitability.

Pooling makes also a lot of sense marketing-wise, as larger fleet and dedicated organization lead to higher visibility with higher market profile, which in turn helps to finalize the deals with customers. This increases the "deal flow" and also enables access to unquoted business.

The higher visibility and larger size in the market leads to higher perception of reliability, whether it is justified or not. This is due to a larger operation, confidence in availability of tonnage for made contracts and financial stability. These matters naturally correlate to some degree, as pools often have more personnel working on chartering, marketing, operations, accounting and supporting systems than a single shipowner. All of which lead to increasing perception of professionalism of service.

The pool has more options for its offering, as it can offer shipping solutions of larger variety by type, duration and volumes that are on a stable industrial level - contrary to single-owner's typical ad-hoc-based situation. In the long run customers are valuing reliability and predictability, which means they are ready to pay premium for these traits in their preferred service provider.

The increased size of the fleet also enables to use it more efficiently with less wait time and ballast voyages, due to more flexibility and availability of vessels.

Pool contract can also act as a guarantee for acquiring or stabilising financing from a commercial bank.

Charterer's perspective

Maybe surprisingly, charterers have been reacting mostly positively to the increase of pooling. This has been linked to their requirement and secondary benefits of a strong and financially stable shipping industry. Charterer's need for security in adequate available tonnage, and on the other hand their preference for certain level of transportation services can usually only be met by the offering of larger professionally managed fleets.

4.2 CHARACTERISTICS OF POOLING

Although there is no one single definition or form of a shipping pool, all pools share most of the key characteristics:

a) Similar tonnage,
b) Central administration,
c) Joint marketing,
d) Centralization negotiation of freight rates and freight collection, and
e) Revenue distribution, weighing system and fair share. (5)

Similar tonnage

Typically shipping pools are constructed for a certain market segment with a specific ship size or type. This – almost a necessity – is found as a good practice, as similar ships in the pool are possible to be benchmarked against each other in somewhat fair way.

As a consequence, shipping pools have one or few major focus markets, where they concentrate their efforts in order to maximise the effects of co-operation.

Central administration

Pool management is arranged by establishing a pool manager – either one of the members or by forming a separate pool management company, PMC. The pool manager is an entity responsible for the daily operations in behalf of the individual shipowners excluding technical management

If a member-controlled pool is chosen, one of the members is elected to act as a pool manager with a mandate from other members. Typically pools opt for the formation of a neutral PMC, where the members are shareholders.

Shipping pools are categorised according to their management structure as member-controlled and administration-controlled pools, respectively. (6)

Joint marketing

Joint marketing is considered to be the single most important characteristic of a shipping pool. The pool is acting as one entity towards customers and other related parties. The marketing is centralized and done by the PMC as if the ships and the services of the pool would be offered by a single company comparable to a traditional ship-owner.

Centralised negotiation of freight rates and voyage costs

As pools have more tonnage and more market share, they have stronger bargaining power in the market than that of an individual ship-owner. The negotiation of freight rates to customers and voyage costs of ship operations are centralized to the PMC. The benefit of centralisation is the PMC's better ability to get higher prices for freight rates in exchange for better services, and on the other hand get bunker fuel with lower price, when buying in bulk for the whole fleet.

Revenue distribution, weighing system and fair share

All earnings from vessel employments are paid into a single account, wherefrom the variety of expenses are paid before paying the member shares. The very key characteristic in pooling is weighing system for ships and a concept of *fair share.* As the PMC is responsible for freight collection and revenue distribution, the differences in the vessels and in their employments mean that the vessels' earnings need to be weighed in order to reach agreeable terms for cooperation.

4.2.1 Pools within pools

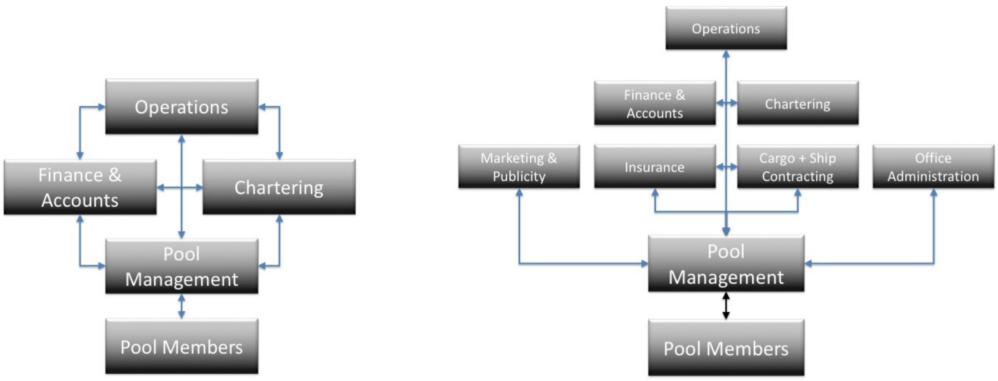
Although pools are structured with similar tonnage, there is a possibility of pools existing inside pools, which would enable different ship types to form their own pools, but still being managed under one umbrella pool company. (8)

4.2.2 Co-operating pools

There are examples of co-operating pools with differing focus areas, such as in the case of Norwegian Western Bulk Carriers and Norwegian Ugland Bulk Transport. With their different focus areas of Atlantic and Pacific, they are not cannibalizing each other, but try to fix each others vessels in their respective operating area when possible. (8)

4.3 Pool structure & Management

All of the shipping pools have very similar structure. There is the central administration of a sort controlling the vessels in the pool via either a commercial management agreement or a modified time charter party. The difference between the two is minuscule, as the end result with both options are very similar in practice. If time charter is opted, the charter hire is set to be a variable amount based on pool earnings using pre-agreed weightings, which are discussed more in detail in the next chapter.



Figures 4.2 & 4.3 Typical pool internal management structures for small (left) and large (right) pools. Redrawn. (7)

All pools – big or small – have certain functions in their structure in one form or another: operations, finance & accounts, chartering, pool management and the members as the fleet. Larger pools may have also distinct divisions for marketing, insurances, cargo and ship contracting, and general administration for the whole office and staff. The main divisions for typical small and large pools are shown in Figures 4.2 and & 4.3. (7)

The Figure 4.4 illustrates the general pool structure with ships, pool committee, pool manager and the charterers. At the top of the figure are the charterers and CoA customers, which are the primary source of income. The income and expenditure flows are illustrated in Figure 4.5. The figure also shows how traditionally the income of ships and profits of management are inherently different, as ships' income comes from the distributions, but that of management comes from the internal fees.

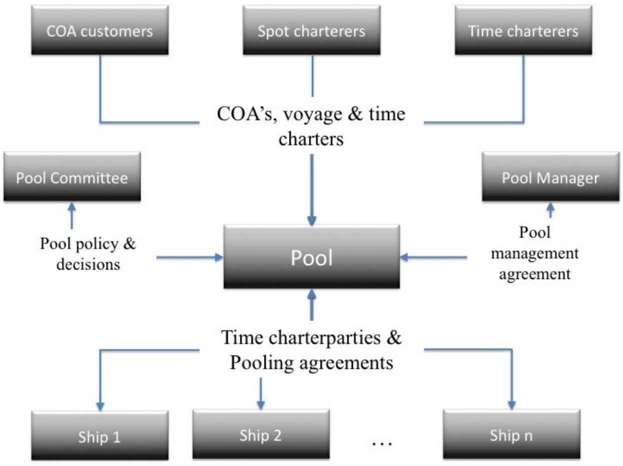


Figure 4.4 Pool Structure in relation to other related parties. Redrawn. (5)

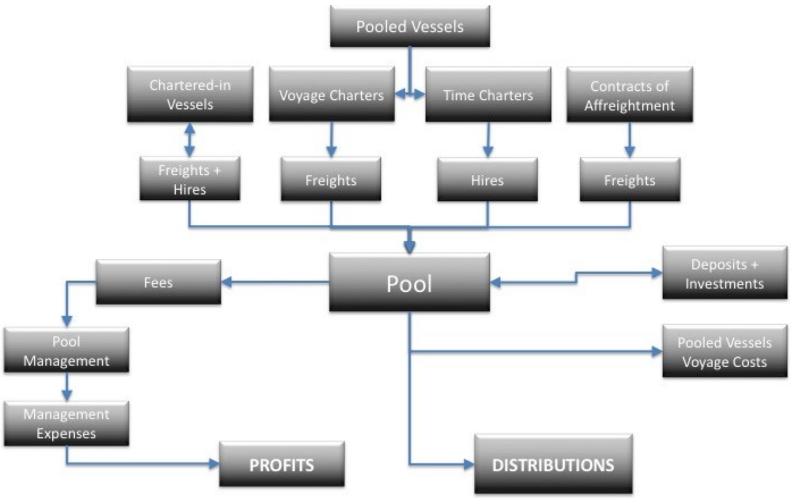


Figure 4.5 Typical pool income and expenditure flow-chart. Redrawn. (7)

4.3.1 Member-controlled Pools

In the simplest form of pooling, two ship-owners come to an agreement to pool their vessels and they further agree that one of the owners acts as a pool manager taking responsibility of the pooled fleet. The dominant member is many times pursuing a *critical mass* by taking one or more smaller owners aboard in order to be able to take a new or maintain an existing contract of affreightment as a long-term-commitment and financial security.

In these pools, such as The Norwegian HUAL car-carrier pool carrying Toyotas, the pooling agreement and the specifics are considered as secondary of importance, as the long-term customer-relationship and mutual benefit is seen more important than penny here or another there.

4.3.2 Pool Management Company and administration-controlled pools

In contrast to many member-controlled pools, administration-controlled pools are seeking to expand and attract new potential members, in order to gain bigger market share. In most pools, central administration is organized by forming a pool management company, *PMC* – a single-purpose entity – which takes responsibility of the commercial management of the pool. PMC is acting as a chartering company responsible for the management of the commercial activities of the pool, such as:

- Market research, whether engaging in or interpreting third party one;
- Gathering and disseminating market intelligence to members;
- Strategy alternative proposals to the pool committee; and
- Marketing program suggestions and their execution.

Many well-managed pools are able to attract private and corporate investors even outside shipping markets – something that traditional shipowners have struggled throughout the history with – and some pools are listed in the stock markets, as well.

4.3.3 Pool committee

Pool Committee is a body, which comprises of representatives of all members, usually convening once a quarter. The role of the pool committee is to make the decisions regarding pool policy and important commercial matters. These include decisions about e.g. fleet size, type of employment contracts and business strategy. Following is a list of commercial strategy decisions, that are in the centre of decision making process. (8)

Fleet size decisions are dependent on planned activity and the geographic spread of said activity, preferred commercial focus and what kind of customer needs are expected.

Type of employment contracts are chosen on the basis of whether the Pool is interested in securing earnings by taking period cover via time charters, riding shipping cycles by keeping its fleet in the spot market or to perform a transportation service – with an element of forward earnings cover – by taking of contracts of affreightment.

Another aspect to consider is the *preferred period of forward revenue cover*, which is closely related to the choice of employment engagements. It can be achieved via the suitable selection of time charters, contracts of affreightment or consecutive voyage charters, according to perceived direction of markets, risk posture of constituent owners, customer preference, or element in fleet deployment strategy.

Pool needs to also establish their *strategy for chartering-in vessels*. The third-party vessels are chartered in in order to increase operational leverage, assert a stronger presence in certain markets and to ensure ability to perform current and future contracts.

Trading area is closely linked to the fleet size, cargo and customer focus decisions. The choice of geographic focus of operation may help to adopt a higher profile and to muster greater broker and charterer support.

The choice of cargos to carry and *the choice of customer focus* are in the epicentre of pool's commercial strategy, as they are the key to concentrate efforts on specific customer in order to penetrate a certain market and trade.

Other strategy decision includes e.g. the use of paper markets to hedge earnings exposure and bunker cost volatility. All the above-mentioned strategy decisions are interconnected, so choices on one aspect will affect the options available for the others.

4.4 Pool points and distribution systems

This chapter describes the distribution systems used in shipping pools, according to the literature and talks with industry representatives, that have been working with shipping pools operating in the Baltic Sea region, but who wish to stay anonymous.

The distribution system is the most distinctive characteristic of a shipping pools, and plays a very significant role, as that is the decisive factor defining the income of pool members. Figure 4.6 illustrates the pool cash flow, and how the distributions are situated in relation to other money flows of a shipping pool.

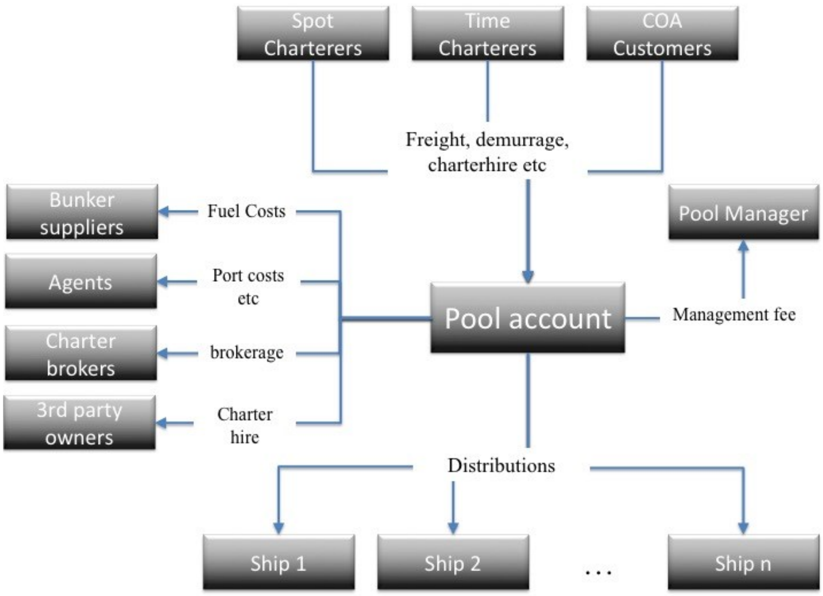


Figure 4.6 Pool cash flow. Redrawn. (5)

Pool points are calculated in order to obtain the fair share of distribution to be shared for each ship. The key principal is illustrated by the equation 4.1below.

$$Share\ of\ distributions\ [\%] = \frac{Individual\ ship's\ points}{Sum\ of\ all\ ships'points} \qquad 4.1$$

4.4.1 The basics

The pool point system is constructed for pools, in order to determine how to divide the finite amount of pool earnings in a fair way in regards what the parties are bringing to the table. One key thing here is to remember that pooling is usually based on interest in mutual benefit and the point is not to compete inside the pool, but against other players in the global shipping market. According to (5) the experience have shown that for most pools the determination of pool points is relatively free of controversy. This does not mean, although, that it could not be improved. Even though, in the short run the pool points are calculated as a zero-sum-game, it can still have an incentivizing effect in the long-term, which means that the secondary effects could be beneficial.

On the other hand, it is also stated that pool points need periodical re-assessment, as ships' speed-consumption-relation is not linear, and the optimal speed figure is dependant of the market situation. (5)

As Haralambides (8) describes: "The purpose of a weighing system is to evaluate and quantify each ship's relative commercial attractiveness, i.e. its income generating potential, and on the basis of this to assign weights or points that would determine the ship's share in total pool income."

4.4.2 The reference ship method

The most used prevalent distribution system is *the reference ship method*, where a characteristic ship – real or imaginary – for that specific pool is chosen. Ships in the pool are scored against that reference ship. The different parameters of the calculation represent the factors such as ship's size, cargo capacity and cargo versatility. The principal factors are listed below:

- Deadweight,
- Draft,
- Cubic capacity,
- Dimensions: LOA & Beam,
- Speed & Consumption,
- Coatings and condition,
- Number of cargo holds or tanks,
- Cargo segregations,
- Pumps or cargo gear (number, type and capacity),
- Existence and capacity of bow thruster,
- Special design features (e.g. stern anchor or discharge line), and
- Flag (and attendant trading flexibility). (5)

In addition to these, the vetting status for tankers is upmost of importance, and is typically included in the tanker pool as a criterion. Vetting status is a customer compliance criterion, used especially in tanker market by oil majors to guarantee the ship's safety.

Typically, the reference ship parameters are set equal to 100. Table 4.1 shows an example of pool point calculation, where a pool of three ships are scored and the resulting pool points are multiplied by the amount of days the individual ship has been on hire. The total points are summed and each vessel's shares are calculated as percentage of the total amount of distributions. The vessels and figures are exemplary and are not related to the pool and distribution calculations discussed later in this study.

Table 4.1 Example of a pool point and distribution calculation. (7)

EXAMPLE FOR DISTRIBUTION THE POOL RESULT				
Pool Result	1 000 000,00			
	Vessel 1	Vessel 2	Vessel 3	Total Pool Point points gained
Vessel's Pool Points	100	90	90	
Vessel's Days on hire	23	30	29	
Vessels points total	2300	2700	2610	7610
Vessels share of total	30,22 %	35,48 %	34,30 %	100,00 %
Vessels Share of Pool Result	302 233,90	354 796,32	342 969,78	

4.4.3 Speed and consumption assessments

Speed and consumption are variables that are proven to be hard to include in the pool distribution systems, mainly due to the fact that while most other factors are constant or change very rarely, speed and consumption are constantly changing – and as the bunker cost is the single most significant cost of a ship – it should not be neglected altogether. This is not helped by the facts that speed and consumption are highly and not linearly interdependent and ships almost never sail at their design draft and speed.

There are few ways to tackle the situation, by:

a) Excluding the speed and consumption factors (and hope for the best),
b) Including the indicated speed and consumption figures as parameters among others,
c) Making a separate performance statement, as explained by Packard (7), or
d) Building a dynamic model based on true measurements and operational data.

Exclusion of speed and consumption figures

The rationale behind this alternative is clear: simplicity and ease of use. As neglecting by one party in the pool hurts all parties – including herself – there is no need to take the consumption and speed into account, as everybody is doing their best.

The problems here are, that while this probably works for small pools relatively well, leaving the responsibility of something to a party that is not actually accountable for it is usually not a good combination. The second problem is that the speed-consumption-problem is complex and very difficult to optimise without some kind of benchmarking.

Inclusion of indicated speed and consumption figures

This alternative means that the indicated speed and consumption figures are weighted among other factors in a similar way. While this keeps the system still simple, it bears many issues, which are not just psychological as in the case of exclusion.

The indicated speed and consumption figures are the design parameters, which are used when the ship is ordered, and while their criteria are at least partially fulfilled during sea trials, the ships rarely see those design conditions: full draft, almost maximum speed and calm water, as recent studies (25) have indicated.

This in addition to the fact that ships' performance deteriorates due to the hull fouling and equipment wear and tear. As a result, the level of technical management makes these indicated figures not representative of the real situation, thus being bad basis for distribution scheme.

Separate performance statement

This method calculates the days at sea, days with adverse weather, ballast days and days in port and calculates the" model" consumption (see the reference ship method) for that ship and compares that to the realised consumption by using average bunker cost. The idea is to sum the result with the attained pool distribution and pay extra or less for said ship according to the fuel consumption. The calculation steps are shown in the Table 4.2 for example vessel, that has no relation to ships later discussed in this study. The method is explained in detail by Packard. (7)

While the method takes into account the true consumption, it is based on static set of speed and consumption figures. It also divides ship's operation as a binary laden or ballast, which means there is a hard line to be put somewhere. Also, while not the preferred option, ships do sail at times only partially loaded, which leaves room for interpretation, whether for example 30% load level is ballast or laden. This also opens the possibility for operator to seek *adverse weather* en-route in order to lower the bunker cost sum. Adverse weather is defined as weather conditions with wind speeds at Beaufort scale 5 or more, equalling 8 m/s.

Table 4.2 Exemplary pool vessel performance assessment. Rewritten. (7)

Year	1						
Distribution	9						
Month	September 1994						
Date	3.10.1994						
Currency	United States Dollars						
Vessel	Panda						
Owners	Abacus Trading Corporation Inc., Panama						
Analysis	8						
Period	From 0001 hrs 01/08/94 To 2400 hrs 31/08/94 (31.00 days)						
Days at sea laden	20,5						
Adverse weather	4,5						
Laden Days	16						
Days at Sea Ballast	6,5						
Navigating restrictions	0,5						
Ballast Days	6						
Days in Port	4						
Operating Days	31						
			Consumption		**Daily**	**Days**	**Consumption**
Bunker Grade	**Target Speed**		**Vessel**	**Model**	**(L)/S**		**(Lost)/Saved**
f/o 180 c/s	13	**L**	32	29,75	-2,25	16	-36
	14	**B**	35	32,25	-2,25	6	-16,5
d/o at sea			2,5	2	-0,5	27	-13,5
f/o in port			0	1	1	4	4
d/o in port			2,5	1	-1,5	4	-6
Assessment							
Bunker Grade	**(Lost)/Saved**		**Average Price**	**(Loss)/Saving**			
f/o 180 c/s	-48,5		$ 62,50	$ -3 031,25			
d/o	-19,5		$ 115,00	$ -2 242,50			
total				$ -5 273,75			

Dynamic performance model

The fourth, and proposed option is to build a dynamic performance-based model which automatically accounts for the performance in a meaningful way. This means that there is no set level of model or design values, as those have no meaning in the real world application. The model is based on actual amounts of cargo carried, fuel burned and distance sailed, as these are the factors that actually matter. IMO's Energy Efficiency Operational Index EEOI is used in the process, as it is widely accepted as an efficient way of benchmarking the operational performance of the ships. EEOI is described more in detail in the previous chapters.

The underside of this system is that it introduces some level of complexity and into the system, and some base requirements need to be met by both all the ships in the pool and the administration. These include reliable on-board data gathering system to monitor the fuel consumption, position and amount of cargo of the ships.

The positive side of this kind of system is that it accounts automatically performance improvements achieved by members of the pool, thus reducing the need to re-negotiate the distribution model every now and then. It also excludes subjective definitions such as ballast or laden, and leaves the ship operator free hands to use tools such as route, speed and trim optimisation in addition to regular scheduled hull cleanings to keep up the good performance of the ship. The system also neglects the current bunker price level, as the operator is not the first-hand-responsible for paying the bunker costs – reducing the fallacy of freedom of responsibility when bunker costs are low.

As stated by Packard (7): ”There may well be a debate among those involved with a pool, however, about the wisdom of including speed and consumption figures into weighting calculations. Once incorporated, it is likely that one ship will have a permanent inbuilt advantage or disadvantage”, and continues:” not only that, but the relative value of a better performance … will change regularly as bunker prices alter”.

5 VLCC TANKER POOL

In this chapter, the construction of the example pool, the pool itself and the dataset of the ships' operational data are described. Also the study period of nine months' operations is analysed as a background for the evaluation of the distribution schemes.

5.1 CONSTRUCTION OF THE EXAMPLE POOL

In this work the pool operations are studied by constructing a crude oil tanker pool – referred as *VLCC Pool* – using real cargo ships and on-board data measurements from those as a source of data.

The pool consists of 5 very similar VLCC crude oil tankers of 320 000 deadweight tonnage from two owners. The similarity between the ships helps when different distribution schemes are compared, as the ship characteristics play very little role, emphasizing the role of the operational differences.

Operational data

Operational data was exported from NAPA Office System in .xls format and further handled and managed with a code written in MS Visual Basic. The principal tasks for the code were:

- to standardize the data sheet layout,
- to calculate average draft and total fuel consumption for given hours,
- to list and calculate laden, ballast and in port days,
- to list voyages, and to calculate voyage-specific figures, and
- to calculate the pool summaries, performance assessments and pool point distributions.

Ships used in the example pools were chosen according to the ship type and the availability of suitable operational data from NAPA Office platform. As the data service itself is *business as usual*, the measurement or reporting methodologies are not in the scope of this work. The required measurements and status reports are listed with explanations in the Table 5.1 below.

Table 5.1 Measurements and status reports used in this study.

Measurement / Status	*Unit / parameters*	*Alternative*
Phase of Voyage	At sea / In port	-
Cargo (if available)	Metric ton [mt]	Estimation from draft measurements
Draft Aft / Fwd	Meters [m]	-
Distance	Nautical mile [nm]	-
Total Fuel Consumption	Metric ton [mt]	ME, Aux, Boiler Consumptions [mt] / Fuel Mass Flow [mt/h]
True Wind Speed	[m/s]	-
Speed over Ground	[kn]	-

Phase

Phase is used to describe the status of the ship during the sea voyage. *At sea* and *in port* are used in this work. These are defined by the NAPA Office system according to location and vessel speed.

Distance [nm]

Distance is the distance that the ship travels in said period.

Draft [m]

Draft is measured both in aft and bow of the ship, slightly depending on the ship in question. In calculations average of the two is used if not otherwise stated.

Total Fuel Consumption [mt]

The total fuel consumption is used, either as a straight output from the system or as a sum of those of main engine, auxiliary engine and boiler, when total figure is not available. For all the vessels it is assumed that only HFO is used, as that is the industry standard in bulk shipping, and the usage of different fuel grades would not bring any added value for the study.

True wind speed [m/s]

Wind speed is used to determine whether the ship has encountered *adverse weather*, defined as the wind speed being more than 8 [m/s], Beaufort scale 5 or more.

Amount of cargo [t]

The amount or cargo is either indicated by the measurement from the database, but as that information is not indicated for some of the ships, the amount of cargo is estimated according to the average draft of the vessel for the purpose of this work using the following principles and given equation:

1. The shallowest draft that has been used is set to be *zero load*, while the design draft is used as to indicate *full load*. *Load level* is indicated as a percentage of *full load*;
2. The load level percentage is used as a multiplier for the maximum cargo capacity in tons, thus giving an estimate of the amount of cargo on-board.

$$Load\ Level: LL = \frac{D - D_{min}}{D_{max} - D_{min}}\ [\%] \tag{5.1}$$

$$Amount\ of\ cargo: C = LL * CC\ [t] \tag{5.2}$$

3. The division between *laden* and *ballast* conditions is set at load level 20%, under which the ship is considered to be in ballast condition and vice versa.

5.2 BENCHMARKING AND KEY PERFORMANCE INDICATORS

A set of key performance indicators are defined to be used to both analyse the fleet operations and to form a basis for the following distribution scheme development. The aspects of interest are energy efficiency of operations, and the utilisation of pool fleet.

Energy Efficiency Operational Index – EEOI

The energy efficiency is benchmarked using the IMO's Energy Efficiency Operational Index, which was described more in detail in chapter 3.3.2 EEOI – Index for operational efficiency. EEOI is the chosen as it is simple yet effective, accounting for the use of different fuel grades and the transportation work done. The smaller the EEOI is, the better the efficiency.

Time Utilisation Rate – TUR

In this study, a time utilisation rate is used to indicate which portion of the on-hire time the ship has been *at sea*. This is indicated as $TUR_{At\ sea}$ and is calculated according to equation 5.3.

Voyage Capacity Utilisation Rate – VCUR

The utilisation of pool fleet is benchmarked using a set of utilisation rate figures. First of these is the *Voyage Capacity Utilisation Rate, VCUR.* The purpose of it it is to calculate the average utilisation rate of cargo carrying capacity per set of voyages. It is calculated using the equation 5.4, where *C* is the amount of cargo in metric tons, *CC* is the cargo capacity in metric tons and *j* is the voyage number.

VCUR is a clear indication of how well the ship's capacity is utilised, and also which amount of the voyages roughly are *laden* and *ballast*.

Ton-miles – TM

Ton-miles is industry-standard unit of transportation work, indicating how much cargo is carried over a distance. Unit is typically metric tons for cargo and nautical miles for distance.

$$TUR_{At\ sea} = \frac{t_{At\ sea}}{t_{on\ hire}}\ [\%] \qquad 5.3$$

$$VCUR = \frac{\sum_j C}{\sum_j CC}\ [\%] \qquad 5.4$$

where:
t = time spent,
C = amount of cargo in metric tons,
CC = cargo capacity in metric tons, and
j = number of voyages.

Freight value – FV

Freight value is used to calculate the pool points for the management, described later in chapter 0. The freight value is estimated using monthly WorldScale spot rates for VLCC tanker on the route from Arabian Gulf to Japan. WorldScale as a concept is described in chapter 2.12, WorldScale. The freight value is calculated using the dollars per ton-mile [$ / (t * nm)] figure obtained from WorldScale data to approximate the market value of the freight contracts of the pool per month. Freight value is estimated using the equation 5.5.

As the monthly WorldScale figures for the study period are publicly available only in the form of figure, the absolute WorldScale monthly values are based on the information found in OAPEC's monthly bulletin, shown in Figure 5.1. (26)

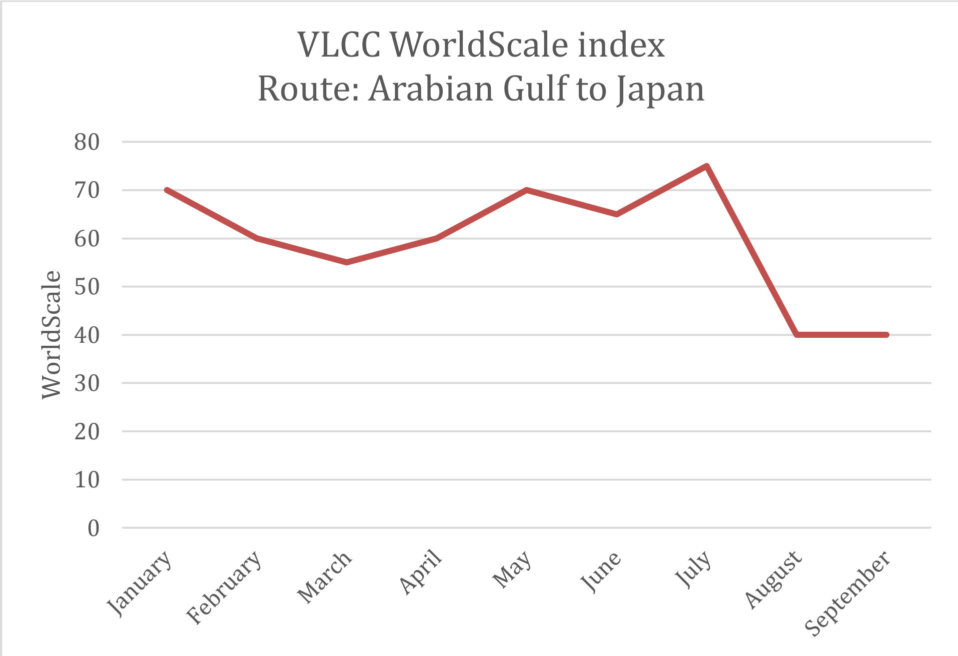


Figure 5.1 WorldScale index for a VLCC during the study period for a route from Arabian Gulf to Japan. (26)

$$Freight\ Value: FV = TM_{Month} * UC_{Month,\, VLCC_{AG-Japan}}\ [\$] \qquad 5.5$$

where:
TM = ton-miles, and
$UC_{Month,\, VLCC_{AG-Japan}}$ = Monthly unit cost for transporting ton of crude oil from Arabian Gulf to Japan.

Pool Income

Monthly freight value is used to estimate the pool income. The freight value is used as monthly revenue and the cost structure was estimated by a broker working in the industry. The figures are obviously rough ball-park figures, as in real world pool would have the necessary information readily available.

The cost structure calculation in table 5.2 assumes 20 day voyages back and forth, 5 day port time, fuel consumption figures for heavy fuel oil (HFO) and marine diesel oil (MDO) are obtained from 9-month averages for VLCC Pool fleet and port cost are approximated at 100 000 dollars for loading and unloading ports. Constant bunker fuel price is assumed.

Table 5.2 Ball-park figures for VLCC voyage cost structure on a route from Arabian Gulf to Japan and back.

Parameter	Value	Unit
Days at sea	40	d
Cost of HFO	$150,00	$/mt
Amount of HFO	106	mt/d
HFO Cost	-638 584	$
Days in port	5	d
Cost of MDO	$300,00	$/mt
Amount of MDO	16	mt/d
MDO Cost	-23 345	$
Loading Port Cost	100 000	$
Unloading Port Cost	100 000	$
Port Costs	-200 000	$
Average costs for 45 day voyage	-661 312	$
Monthly voyage costs per ship	-440 875	$
Average daily cost	-14 696	$

Table 5.3 shows the calculation for the monthly amount of revenue available for distributions after voyage costs. For simplification, other costs are neglected, but their existence is acknowledged. The revenue per voyage is obtained from *freight value*, from which 2,5% commissions and voyage costs calculated above are reduced. To approximate the amount of monthly distributions available, the number of voyages is used as a multiplier to obtain the amount of pool profits after voyage costs. The other pool management and related overhead costs are neglected, as they play little role for the scope of this study.

Table 5.3 Summary of monthly revenue and total available monthly distribution calculations.

	Revenue per voyage	*Comissions (2,5%)*	*Costs per voyage*	*No. of voyages*	*Pool revenue after voyage costs*
January	91 764	-103 235	-440 875	5	11 044 099
February	78 655	-88 487	-440 875	1	1 830 292
March	72 101	-81 113	-440 875	3	4 923 084
April	78 655	-88 487	-440 875	3	5 490 876
May	91 764	-103 235	-440 875	3	6 626 459
June	85 210	-95 861	-440 875	5	10 097 780
July	98 319	-110 609	-440 875	5	11 990 419
August	52 437	-58 991	-440 875	2	2 146 473
September	52 437	-58 991	-440 875	6	6 439 419

5.3 SHIPS IN THE POOL

The VLCC pool – which does not exist as such in the real world – was constructed according to data availability of the same ship type in the same size range. The five ships in the pool – marked as A, B, C, D and E for anonymity reasons – are very similar design wise. They are even built by the same shipyard in the time frame of two years, so most probably they are very similar, if not even from the same series of ships.

The ship characteristics are shown in table 5.4. Crude oil tanker was preferred as ship type, due to the fact that crude oil plays major role in international shipping and the price and volume data is widely available. The crude oil is homogenous enough commodity, that in this exemplary case no preference of one ship over another's capability of carrying a shipment can not be made. Also, crude oil carriers rarely take other cargos. All of this helps to limit the variables and making the problematic of the study just a tiny bit simpler.

Table 5.4 VLCC Pool Ship Characteristics

SHIP ID	A	B	C	D	E
Type	*Crude*	*Crude*	*Crude*	*Crude*	*Crude*
Owner	*1*	*1*	*2*	*2*	*2*
Built	*2013*	*2013*	*2014*	*2014*	*2014*
DWT	*320299*	*320299*	*316648*	*316884*	*317019*
Length	*333*	*333*	*333*	*333*	*333*
Breadth	*60*	*60*	*60*	*60*	*60*
Draught	*22,5*	*22,5*	*22,5*	*22,5*	*22,5*
DWT	*320299*	*320299*	*316648*	*316884*	*317019*
GRT	*161974*	*161974*	*165178*	*165178*	*165178*
NRT	*112240*	*112240*	*108113*	*108113*	*108113*
Total Power Mcr [kW]	*26900*	*26900*	*27390*	*27390*	*27390*
Service Speed [kn]	*15,4*	*15,4*	*15*	*15*	*15,9*
Consumption	*104 t/d @ 15,3 kn*	*104 t/d @ 15,3 kn*	*107 t/d @ 16,1 kn*	*107 t/d @ 16,1 kn*	*107 t/d @ 16,1 kn*
Capacity	*341000*	*341000*	*340981*	*340981*	*340900*
Segregations / Grades	*3*	*3*	*3*	*3*	*3*
Total Pump Capacity	*20000*	*20000*	*16500*	*16500*	*16500*

5.4 FLEET OPERATIONS DURING THE STUDY PERIOD

The period of study was chosen to be the first nine months of 2015, as that was a recent period that would have data from all the ships available, and long enough to show some scatter in the operational profiles from month to month, as seen in Figure 5.2 below.

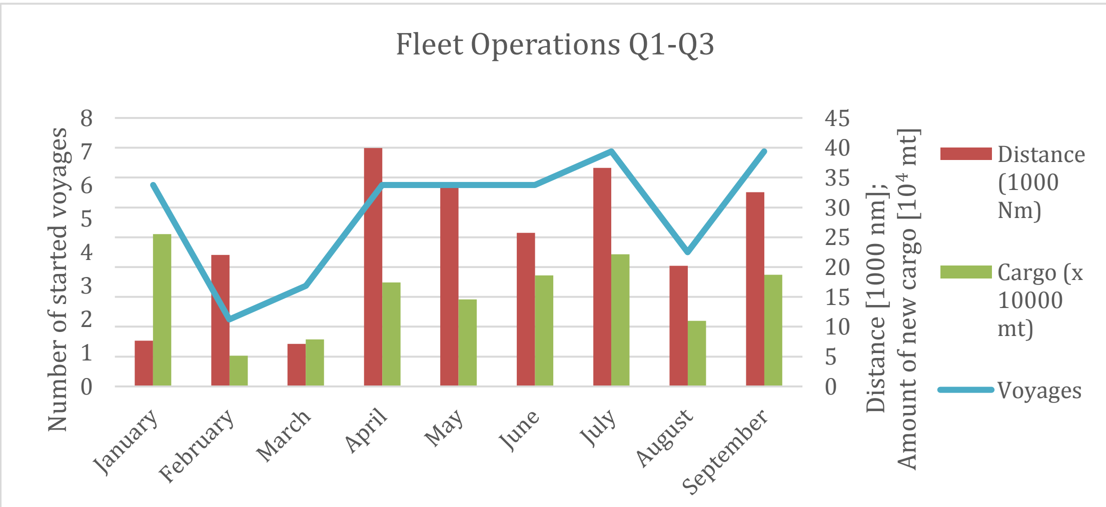


Figure 5.2 Fleet operations during the study period.

Interestingly, there very few voyages and new cargo loaded in February and March. This is probably due to the collapse of oil price during the previous months, as seen in Figure 5.3 representing the monthly average for crude oil price. The distance figures for February and March are not zero as some of the ships were still undertaking voyages started in January and some ballast voyages were conveyed.

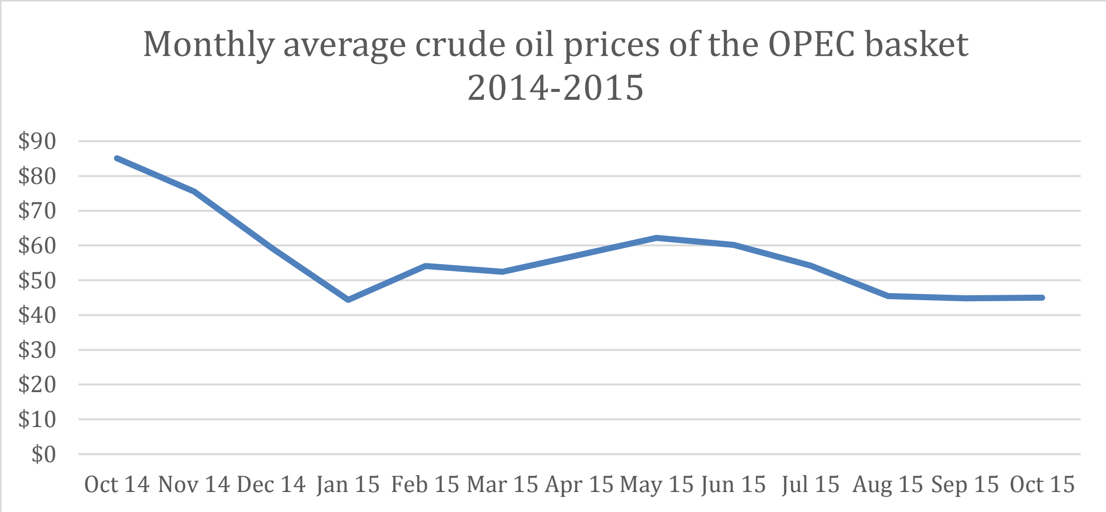
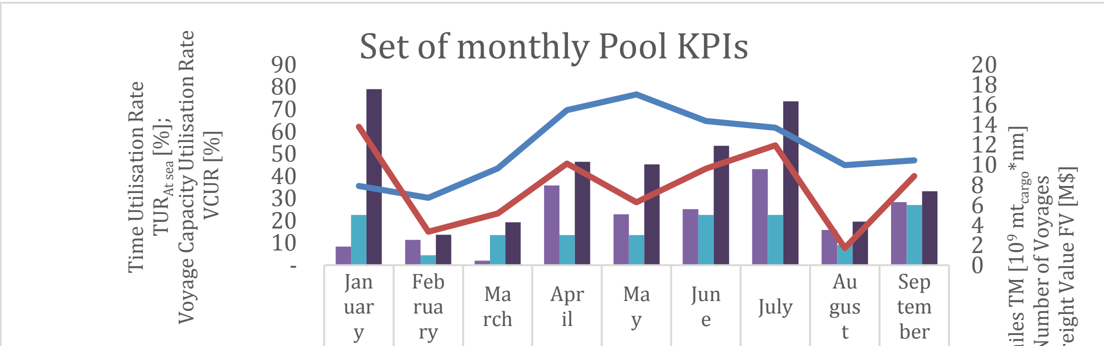


Figure 5.3 OPEC basket crude oil price development from October 2014 to October 2015 (in U.S. dollars per barrel). (27)

Figure 5.4 shows a set of KPIs, *VCUR* and $TUR_{At\ sea}$ and their relation to number of voyages, ton-miles and freight value. The cyclical nature of crude oil shipping sector is clearly visible from the freight value figures, which show a collapse from January to February and to a slightly lesser degree from July to August. Also the monthly fluctuation in fleet activity is noteworthy, as the time utilisation, $TUR_{At\ sea}$, varies between 30,2% and 76,6% while the average utilisation of cargo capacity, VCUR, goes from January high of 62,1% to down to February 15,0% and August 7,64%, indicating very low fleet utilisation.



	January	February	March	April	May	June	July	August	September
TonMiles [10^9 t*nm]	1,83	2,52	0,45	7,93	5,07	5,58	9,57	3,51	6,30
Laden Voyages	5	1	3	3	3	5	5	2	6
Freight Value (M$)	17,5	3,02	4,26	10,2	10,0	11,8	16,3	4,32	7,35
TUR - At Sea [%]	35,4	30,2	43,4	69,6	76,6	64,7	61,6	44,8	47,0
VCUR [%]	62,1	15,0	23,1	45,5	28,1	43,2	53,7	7,64	40,0

Figure 5.4 Set of monthly KPIs in relation to number of voyages and ton-miles.

5.5 Pool points for VLCC Pool

In this instance, there are no major differences between the ships, as can be seen from the Table 4.2, so it does not make any significant difference, whether the traditional pool point system consist of 4 or 40 parameters, as they are basically the same for each ship. Thus the static system is constructed in an exemplary fashion of only five available parameters. The fact, that many more are used in real world pools is fully acknowledged, but using unnecessary complex system serves no purpose here. The selection of parameters used is based on the reference contract, see Appendix A, and the parameters selected for the example model are:

- Ship's age [yr];
- Deadweight tonnage, dwt [mt];
- Cargo Cubic Capacity, CCC [m^3]; and
- Net register tonnage out of gross register tonnage, NRT/GRT [%];

as these are values that are attainable when doing this work, and also to keep the system relatively simple to demonstrate the dynamic part. The age is scored according to the attained pool contract, as follows:

- Under 5 years old 100 points,
- 5-10 years old 50 points, and
- 10-15 years old 10 points,

multiplied by the weight factor. All the other static parameters are calculated using the general formula:

$$points = weight * \frac{ship's\ parameter\ figure}{average\ of\ the\ pool} * 100\ , \qquad 5.6$$

giving the equation for dwt points as an example:

$$DWT\ points_{ship1} = weight * \frac{DWT_{ship1}}{DWT_{pool\ average}} * 100 \qquad 5.7$$

The reference ship method is used, and as the set reference does not play a significant role in this study, a simple average was used for its ease of use. In a situation like this, pool could neglect the minor differences and agree on equal shares for now, but would need to re-assess the situation if a ship with significantly differing characteristics should join the pool.

Table 5.5 shows the resulting static points, 80% of total pool points, for the ships in the VLCC Pool, excluding speed and consumption figures. These are assessed separately and will account for the last 20% of the points when applicable.

Table 5.5 VLCC Pool static pool points, with unweight points showing for each parameter. Total is a sum of weighted points.

	Age	*DWT*	*CCC*	*NRT/GRT*	*Total*
Weight:	10%	20%	40%	10%	80%
A	100	100,65	100,01	103,44	80,48
B	100	100,65	100,01	103,44	80,48
C	100	99,50	100,00	97,71	79,67
D	100	99,58	100,00	97,71	79,69
E	100	99,62	99,98	97,71	79,69

5.5.1 Speed & Consumption – Separate assessment

Separate assessment means that speed and consumption are not included in the actual pool point and distribution calculations. Instead, the monthly average values are calculated and bunker costs are paid according to those results separately from the pool account. Separate fuel consumption assessments were done according to the example shown by Packard (7) for each ship monthly. Average sailing speed and consumption values were calculated for laden and ballast conditions. The assessments can be found in the appendix B.

5.5.2 Speed & Consumption – Design Values

The so-called design values are the figures for service speed and consumption that are available publicly for that ship. The points calculated using these are in the Table 5.6 below. The other factors are the same as in previous sub-chapter and are left out from the table for visual purposes. These represent the other 80 % of the points.

Table 5.6 Speed and consumption design values, resulting unweight points and total weighted total points including the static pool points calculated before.

	Speed		*Consumption*		*Total points*
	[kn]	Points	[t/day]	Points	
Weight:		10 %		10 %	100 %
A	15,3	96,96	104	101,73	100,35
B	15,3	96,96	104	101,73	100,35
C	16,1	102,03	107	98,88	99,76
D	16,1	102,03	107	98,88	99,78
E	16,1	102,03	107	98,88	99,78

5.5.3 Speed & Consumption – Time period averages

Actual average values were calculated in similar fashion as in the case of the separate assessments, but averaging over the nine-month period, which represents in a reasonable fashion the prelevant method of assessing roughly once a year the speed and consumption figures that are used for scoring. The summary is in the Table 5.7 below. The other factors are the same as in previously and are left out from the table for visual purposes. These represent the other 80 % of the points.

Table 5.7 Speed and consumption, based on 9-month averages, and pool points taking these into account.

	Laden Speed		*Ballast Speed*		*Laden Consumption*		*Ballast Consumption*		*Total*
Wt.	[kn]	Pts. 5 %	[kn]	Pts. 5 %	[t/day]	Pts. 5 %	[t/day]	Pts. 5 %	
A	12,98	96,66	11,43	82,94	85,87	123,94	52,28	177,10	104,5
B	12,78	95,21	12,42	90,15	79,51	133,86	60,95	151,89	104,0
C	13,88	103,37	15,12	109,75	113,46	93,81	73,28	126,34	101,3
D	13,35	99,41	14,32	103,89	110,64	96,19	125,28	73,90	98,4
E	14,14	105,34	15,61	113,28	142,67	74,60	151,12	61,26	97,4

Below, in Figure 5.5 are calculated the static shares for VLCC Pool's ships as percentages using the three different methods to account speed and consumption. As the separate assessment as money, it will be discussed in the next chapter, where distributions are calculated in dollars.

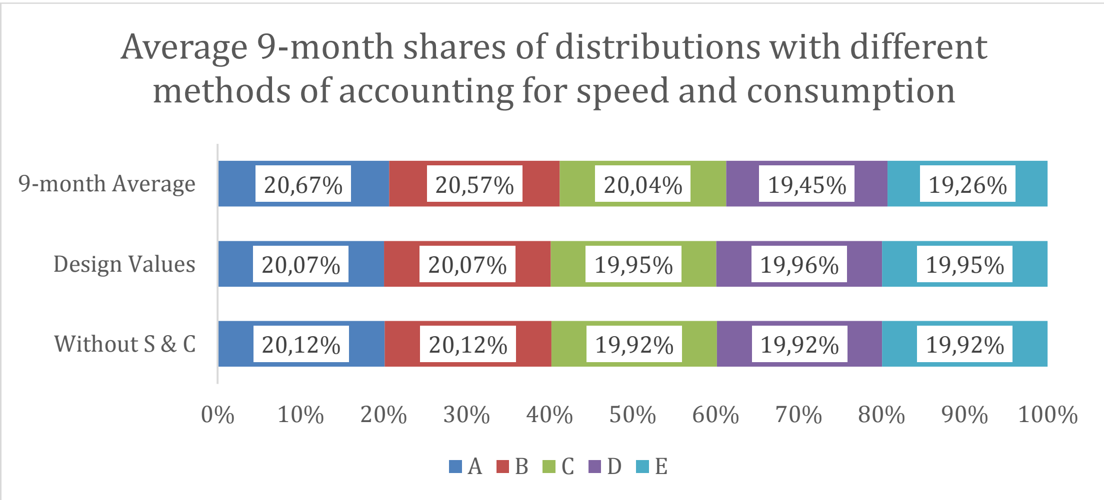


Figure 5.5 Shares of static distributions with different speed and consumption accounting methods. S & C = Speed and Consumption.

6 DYNAMIC PERFORMANCE-BASED DISTRIBUTION SCHEME

In this chapter, the novel distribution scheme is presented. First the basic principals of the system are presented followed by analysis about the results.

Static pool points is used to refer to the standard set of pool points, as described in chapter *4.4, Pool points and distribution systems*, and calculated in chapter 5.4, *Pool points for VLCC Pool.*.

6.1 BACKGROUND AND THE BASIC PRINCIPALS

The proposed distribution scheme acts as an extension to existing ones by accounting for operational energy efficiency in relation to transportation work done, and proposing the inclusion of pool manager into the distribution scheme. The background for are in the following key notions about pools and distributions.

1. Financial performance of a member should be tied to its ship's actual performance – not the design values.
2. The pool manager has a great responsibility to find employment for the fleet, and thus it is not seen reasonable, that the pool manager will make always profit according to a fixed percentage before the ships are paid distributions, with only marginal downside risks.

The resulting proposition for the basis for the novel distribution model is constructed under 3 main principles:

1. The performance of all parties inside the pool is monitored, as they all play a vital role in the profitability of the whole pool,
2. The model should be as simple to understand as possible without sacrificing the point of being focused on the key aspects.
3. The proposed model is constructed to demonstrate the basic principal of dynamic pool points, thus the specific weights and factors are not to be taken as strict values, but are meant to be tailored to suit the different needs of pools with varying fleets, structures and activities.

The resulting system consists of three main parts: static and dynamic parts for both the vessels and the management. These are presented in their own following sub-chapters. Figure 6.1 illustrates the relationships and roles of each part.

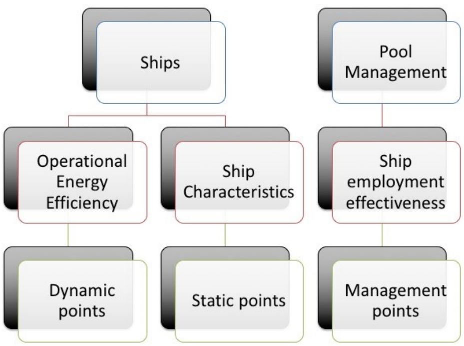


Figure 6.1 Flowchart of proposed pool point calculation.

6.2 Static points

The first part of the proposed distribution scheme is based on industry-standard pool point calculations, as described in previous chapters, where the pool points were calculated for the VLCC Pool with different methods for accounting for speed and fuel consumption figures. In the dynamic model, the speed and fuel consumption are excluded from the static part of the calculation. Table 5.3 shows the static part of the dynamic model, and these are illustrated in the figure 6.2, also.

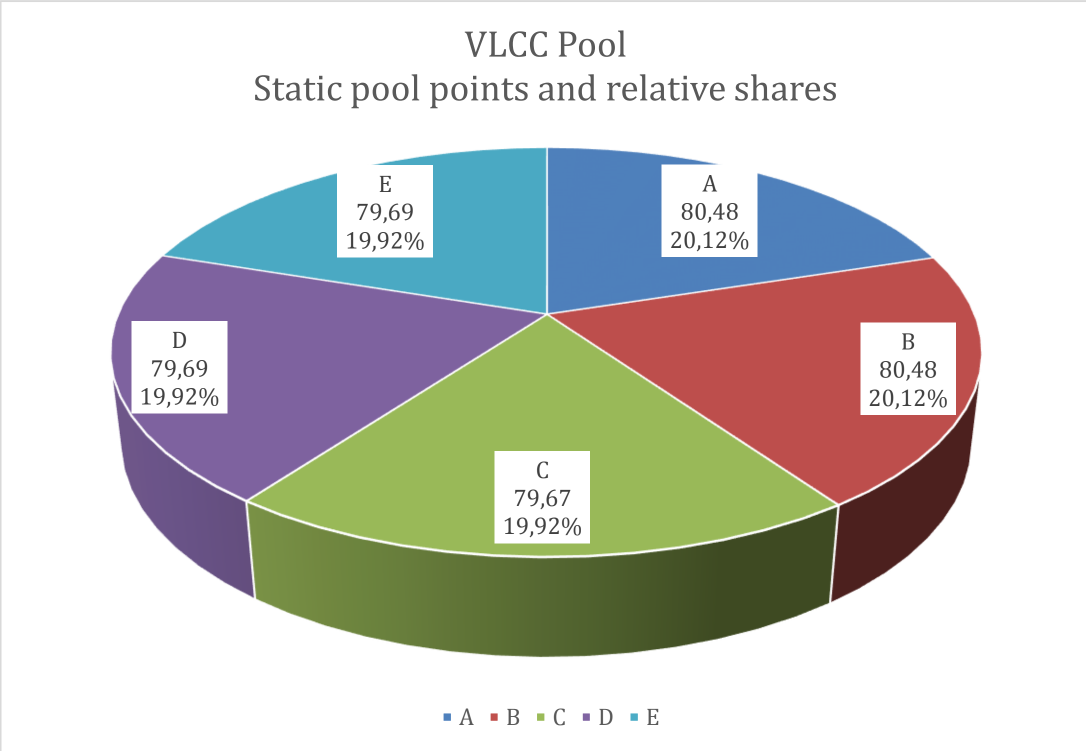


Figure 6.2 The shares of static point system in VLCC Pool excluding speed and fuel consumption figures.

6.3 Dynamic points for ships

The dynamic part of the distribution scheme is constructed with the emphasis on the relative efficiency, as the member-shipowner can not solely make decisions about its employments.

As a consequence, the dynamic points are calculated utilising IMO's EEOI – *Energy Efficiency Operational Index*. EEOI indicates how much CO_2 is emitted for every tons of cargo carried over a nautical mile. This is good and to-become industry standard indicator for ship's operational energy efficiency. This is why it is chosen to be the key metric here.

The use of EEOI neglects the actual amount of transportation work done. This is because the transportation work is taken into account in the denominator, making it in theory possible to achieve the same level of EEOI whether the ship sails for only a few or many voyages. This is seen as a favourable characteristic for a metric as it removes the argument of a member getting paid more because of acclaimed favouring of one owner over another by the management in its process of finding employment for the fleet.

Average EEOI for a number of voyages are calculated using the formulas below:

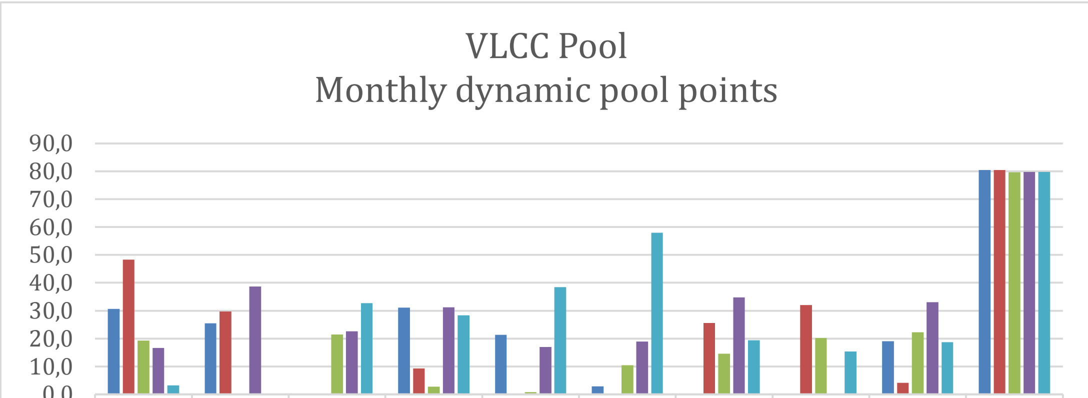
$$EEOI_{Average} = \frac{\sum_i \sum_j (FC_{ij} * C_{Fj})}{\sum_i \sum_j (C_{i,j} * D_{i,j})} \left[\frac{mt_{CO_2}}{mt_{cargo} * nm}\right] \qquad 6.1$$

where:
FC = fuel consumption,
C_F = Fuel carbon coefficient,
C = amount of cargo,
D = distance of the voyage,
i = number of ship, and
j = number of voyage.

The actual dynamic performance scoring for ships is calculated using the equation 6.2 below:

$$Monthly\ Points_{Dynamic} = \frac{1}{EEOI_{Monthly\ Average}} * 100 \qquad 6.2$$

This gives following results for the VLCC pool, as seen as numbers in Figure 6.3. The results are analysed later in this chapter.



	January	Februar y	March	April	May	June	July	August	Septem ber	Static points
A	30,7	25,4	0,0	31,1	21,3	2,9	0,0	0,0	19,1	80,5
B	48,3	29,8	0,0	9,3	0,0	0,0	25,5	32,0	4,1	80,5
C	19,3	0,0	21,4	2,8	0,8	10,4	14,6	20,2	22,2	79,7
D	16,6	38,7	22,6	31,3	17,0	18,9	34,7	0,0	33,0	79,7
E	3,2	0,0	32,7	28,4	38,4	57,9	19,4	15,4	18,8	79,7

Figure 6.3 Dynamic points of VLCC Pool by month. Static points shown also as a reference.

6.4 DYNAMIC POINTS FOR MANAGEMENT

The main idea of the dynamic management points is to make management more accountable for the financial well-being of the pool.

The scoring of the management is not to be found in the literature with the exception of fixed management fee as a percentage of the revenue, as was shown in Figure 4.5 illustrating the pool income and expenditure flows. Figure 6.4 illustrates the proposed way of re-arranging the income and expedinture flows with the main difference being that management fees and expenses are not a separate flow and internal fees as such are removed. Instead, the necessary management expenses are taken out of the pool in the same manner as voyage costs for pooled vessels. What is left after voyages costs and management expenses is distributed between vessels and management according to performance of each. This should even out the incentive gap between ships and management, as both are accountable for their actions and even small incremental improvements are showing without significant delay in the bank account.

It is necessary to note, that the relationship between management expenses and management distributions is the role they play in the big picture: the management expenses cover all the necessary expenses, but only the very bare minimum to keep the pool operational, like rent for the office space and some part of the staff salaries, while the distribution part is seen as the part, where bonuses, investments and dividends are paid from. The definitive division of these two and the allocation of these two should be assessed case by case according to the size and characteristics of the pool, when such a system would be implemented.

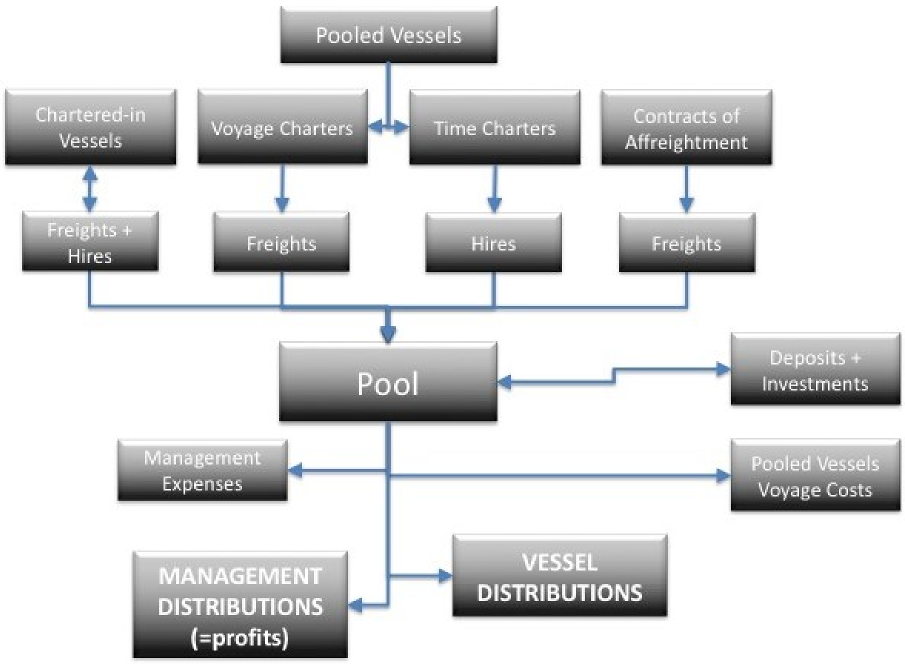


Figure 6.4 Proposed income and expenditure flow chart.

The calculation of management points is based on the utilisation of the fleet and the freight value of contracts of carriage. For this work the actual contract values is not available, so an approximation of monthly market price was created using the the WorldScale, described in self-titled chapter 2.12. The calculation of used utilisation rates and Worldscale are presented in chapter 5.2, *Benchmarking and key performance indicators*.

The metrics for management points are selected on the basis, that the more of the ships are at sea, the better; the more cargo they are carrying, the better; and the more management can bring in money, the better. Naturally, this is a simplification, but the metrics selected to represent these, $VCUR$, $TUR_{At\ sea}$ and FV are mathematically relatively independent of each other, and cover all of the three aforementioned aspects of pool fleet management. This requires that the freight values are transparent between the management and the pool members. The Management points are calculated using equations 6.3 – 6.6 below.

$$P_{VCUR} = VCUR * 100 \qquad (6.3)$$

$$P_{TUR_{At\,sea}} = TUR_{At\,sea} * 100 \qquad (6.4)$$

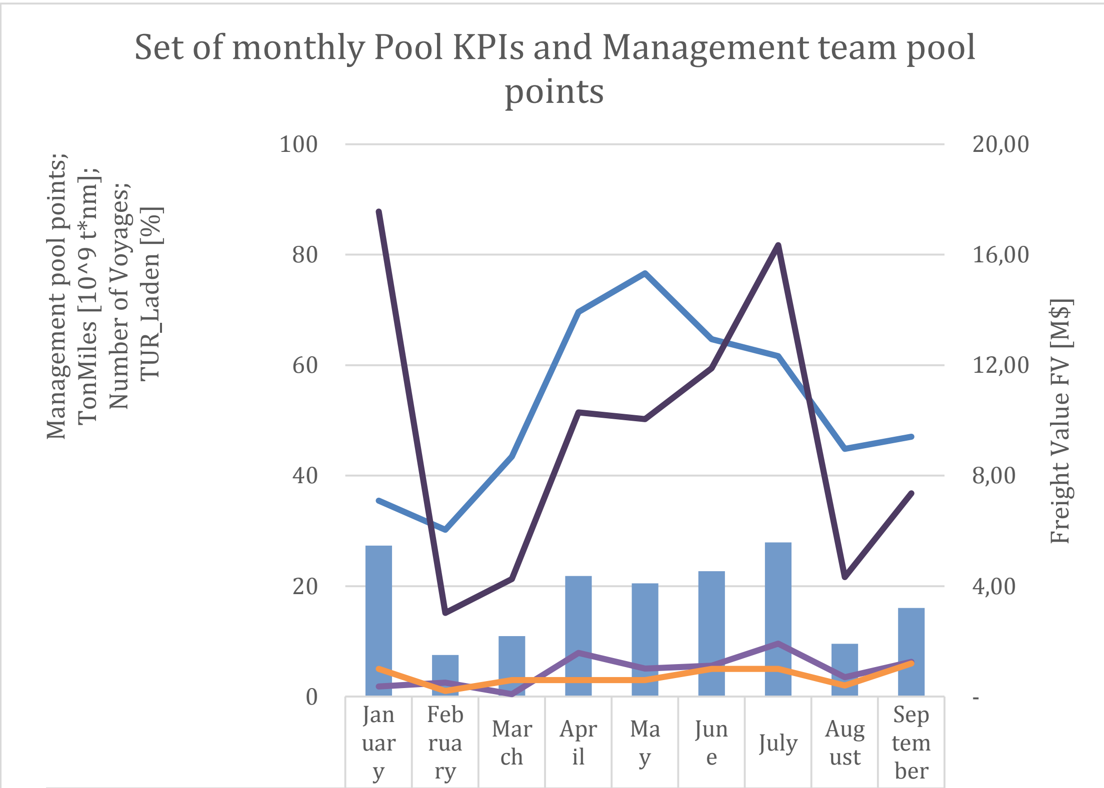
$$P_{FV} = \frac{FV}{10^6} \qquad (6.5)$$

$$Management\ Points: PP_{MGMT} = 0{,}1 * P_{VCUR} + 0{,}1 * P_{TUR_{At\,sea}} + P_{FV} \qquad (6.6)$$

where:

P_{VCUR} = Points according to *Voyage Capacity Utilisation Rate, VCUR;*
$P_{TUR_{At\,sea}}$ = Points according to *Time Utilisation Rate – At sea, $TUR_{At\,sea}$;*
P_{FV} = Points according to *Freight Value, FV*; and
PP_{MGMT} = *Dynamic pool points for management.*

The resulting points are listed and illustrated in figure 6.5 with relevant fleet KPIs showing. The results are further analysed in the next sub-chapter.



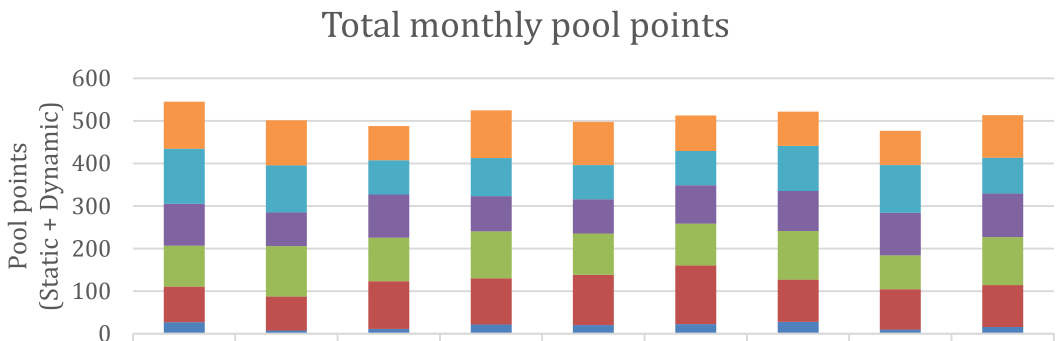
	January	February	March	April	May	June	July	August	September
MGMT points	27,32	7,54	10,92	21,81	20,52	22,69	27,89	9,57	16,06
TonMiles [10^9 t*nm]	1,83	2,52	0,45	7,93	5,07	5,58	9,57	3,51	6,30
Laden Voyages	5	1	3	3	3	5	5	2	6
TUR - At Sea [%]	35,4	30,2	43,4	69,6	76,6	64,7	61,6	44,8	47,0
Freight Value (M$)	17,5	3,02	4,26	10,2	10,0	11,8	16,3	4,32	7,35

Figure 6.5 Monthly management points in relation to relevant KPIs. Freight Value is on the right hand axis.

6.5 TOTAL POOL POINTS AND ANALYSIS

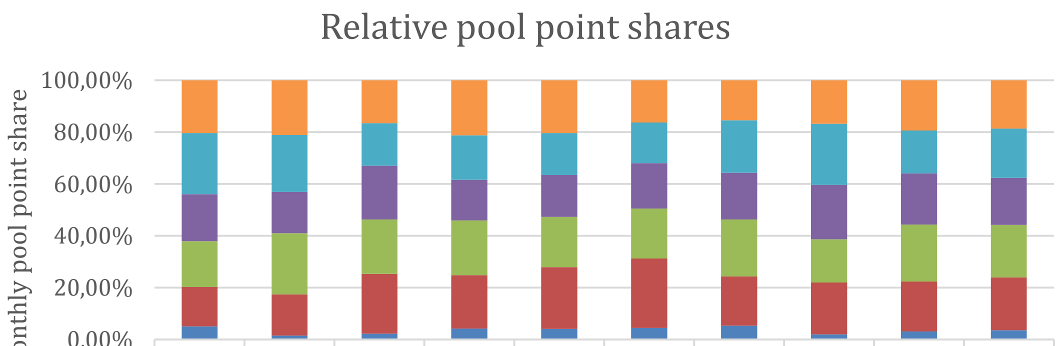
Total pool points are calculated with the assumption of no off-hire times. Also, the use of only one fuel oil grade and constant bunker fuel price are assumed.

The total pool points are calculated by summing the static and dynamic points for vessels, while the management points only consist of the dynamic part. Figure 6.6 shows the total amount of monthly points. As it is clear, the monthly total points show similar trend as the operational statistics from the study period, with February, March and August being difficult times.



	January	February	March	April	May	June	July	August	September
A	111,1	105,9	80,5	111,5	101,8	83,4	80,5	80,5	99,6
B	128,8	110,2	80,5	89,8	80,5	80,5	106,0	112,5	84,6
C	99,0	79,7	101,1	82,5	80,5	90,1	94,2	99,9	101,9
D	96,3	118,4	102,3	110,9	96,7	98,6	114,4	79,7	112,7
E	82,9	79,7	112,4	108,1	118,1	137,6	99,1	95,0	98,4
MGMT	27,3	7,5	10,9	21,8	20,5	22,7	27,9	9,6	16,1

Figure 6.6 Total monthly pool points



	January	February	March	April	May	June	July	August	September	9-Month Total
A	20,38%	21,12%	16,50%	21,26%	20,44%	16,25%	15,41%	16,87%	19,40%	18,63%
B	23,62%	21,98%	16,50%	17,12%	16,16%	15,69%	20,30%	23,57%	16,49%	19,05%
C	18,15%	15,89%	20,73%	15,72%	16,17%	17,57%	18,05%	20,93%	19,85%	18,12%
D	17,65%	23,61%	20,98%	21,15%	19,41%	19,22%	21,91%	16,70%	21,96%	20,29%
E	15,20%	15,89%	23,04%	20,60%	23,71%	26,84%	18,98%	19,92%	19,18%	20,37%
MGMT	5,01%	1,50%	2,24%	4,16%	4,12%	4,42%	5,34%	2,01%	3,13%	3,55%

Figure 6.7 Relative shares of monthly total pool points.

During the 9-month period, the pool distribution shares of any vessel vary between 15,20 % and 26,84 %, while that of management stays between 1,50 % and 5,34 %. When compared to the industry standard system in Table 6.1, we can see that the fluctuations are on a level that is significant, but not that an owner's income would go to zero. The 9-month averages are between 18,12 % and 20,37 % for the vessels and at 3,55 % for the management. This shows, that even though the dynamic system rewards for good and punishes for bad performance, the mid-term averages are at reasonable levels. As for the management levels we can note that one third of the study period had very low fleet activity. Whether this is more or less out of management's control or not, is debatable. Nevertheless, there is very little reason to pay excessive bonuses for management when the pool income is scarce.

Table 6.1 Deviation of monthly pool points for ships and for management. Note that the industry standard figures are based on the static points, and the do not fluctuate.

	Dynamic		***Industry standard***	
	Ships	**MGMT**	**Ships**	**MGMT**
min	15,20 %	1,50 %	18,92 %	5 %
average	19,29 %	3,55 %	19,02 %	5 %
max	26,84 %	5,34 %	19,12 %	5 %

The month-to-month development of distributions is clearly visible in Figure 6.8, where the difference both between months and between vessels are clearly showing. Noteworthy is that none of the vessels is constantly on a higher or lower level, which seems reasonable in the case of very similar ships.

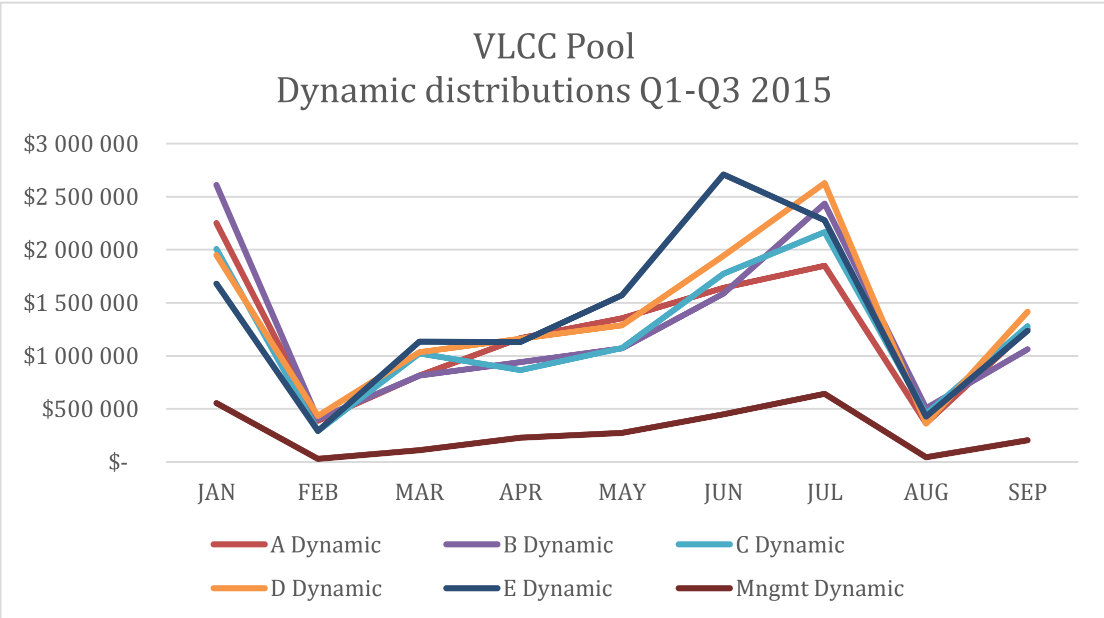


Figure 6.8 VLCC Pool Dynamic Distributions over the study period.

Although, as one of the fundamental reasons behind pooling is to stabilise the income of shipowners, the static part of the distribution system makes sure, that shipowner always gets a fair share, even if the pool is unable to fix any employment for said vessel. Figure 6.7 shows the relative shares of monthly distributions for each party in the pool. As can be seen, the total amount of points is varying significantly in relation to the business activity of the pool. The deviation in the amount of monthly transport activity is clearly indicated by the Management points, which are significantly lower for February, March and August. When comparing 9-month total figures to the overall efficiency and the amount of transportation work done during the study period, illustrated in figure 6.9, we can see clearly that the accumulating score for the study period is in good correlation with the EEOI and transport work figures. On the horizontal axis there is transportation work, tons of cargo carried over a distance in nautical miles. EEOI is indicated on the vertical axis. The only anomaly is that vessel D's share of 9-month total is slightly less than that of vessel E's, which is due to the monthly fluctuation of pool income, as vessel E has happened to be slightly more effective during the months with higher market.

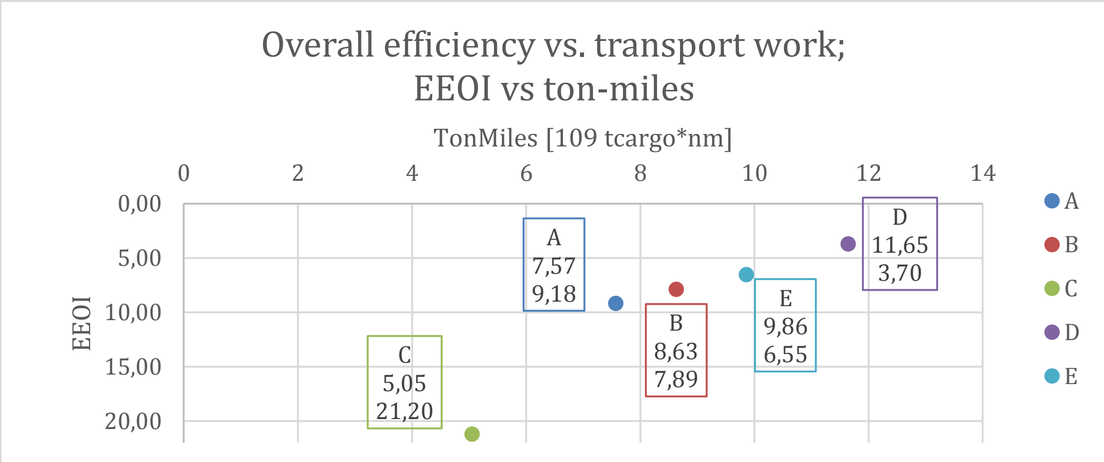


Figure 6.9 EEOI vs Ton-miles. Note: Smaller EEOI is better.

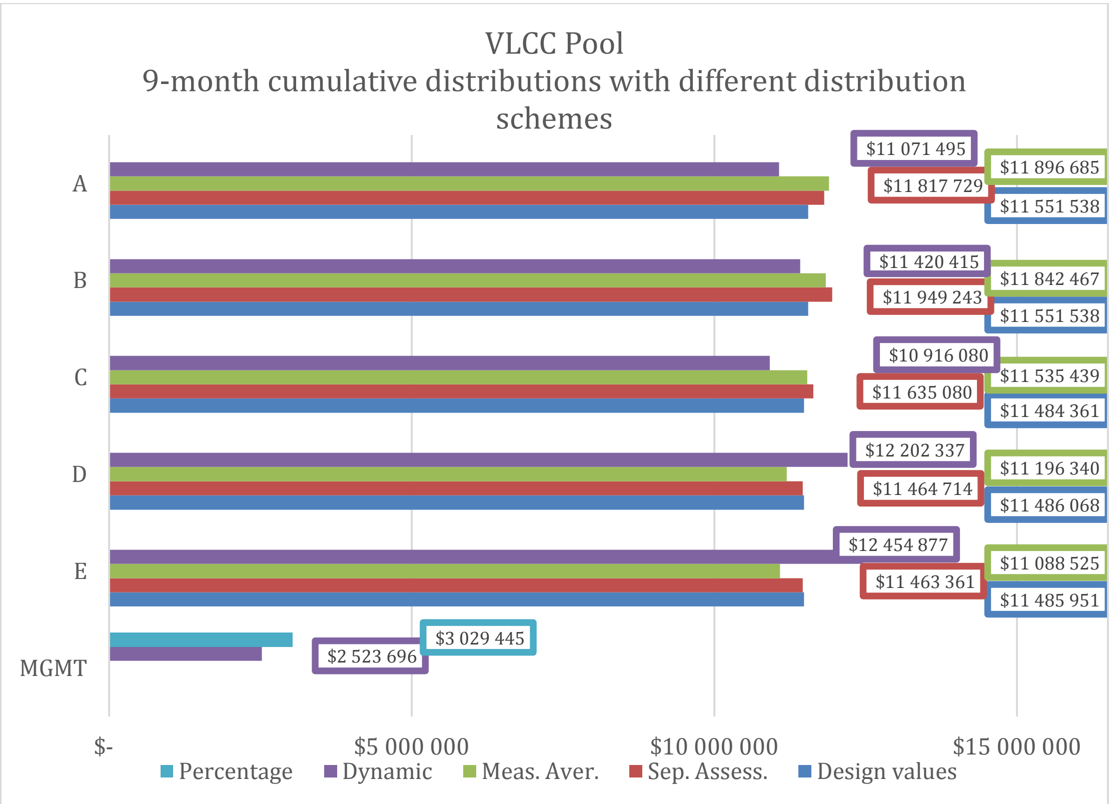


Figure 6.10 Summary of different pool point systems' effect on the 9-month cumulative distributions.

The figure 6.10 summarises the differences that occur when using proposed dynamic distribution scheme versus industry standard models. The interesting part is that while for example vessel A should gain higher distributions according to 9-month averages, the dynamic model indicates significantly smaller share. The dissonance is natural, as clearly vessel A has been able to cut fuel consumption by due the use of slow-steaming or having less cargo. But this also means, that less cargo is transported, and it is no use for a cargo ship to sail empty, no matter how efficiently it is able to do that. The same effect is seen for vessels B and C, while D and E have been burning more fuel, but carrying also significantly more cargo over longer distances, as that is the measure behind the dynamic model.

Important notion is that from the pool distributions, shipowner has to cover all ship-related expenses, such as crewing, financial, insurance, technical, future dry docking and shipowner overhead costs before profits, if any.

Another noteworthy aspect is, that the design values is somewhat close only for vessel C, but that may be a coincidence. The clear signal is that even with among similar ships carrying the same cargo, there are significant differences in the operations, and whether this is due to the effects of hull-fouling, differences in the crew performance or something else, it is important to at least monitor the operational efficiency, whether it is included in to the financial side of business or not.

7 Discussion & Conclusions

As shown in previous chapters, it is possible to construct a relatively simple, yet effective dynamic pool point distribution scheme, that rewards for good operational energy efficiency. Naturally, the amount of dynamics is open for a debate – and is also encouraged by the author – to be adjusted case by case for each pool interested in implementing such a system in their operations.

As shown, the ship owner bears the responsibility to perform the transportation duties as efficiently as possible, in order to maximise its own profits alongside those of the whole pool. While shipowner has limited possibility to freely decide about its employment, it has a variety of ways to increase its operational efficiency by using tools and methods such as route optimisation, trim optimisation and slow-steaming when possible. These are well applicable and available in the short-term, already. In the mid-to-long term the rewarding nature of the dynamic distribution scheme is hoped to encourage valuing the fitness to purpose and fine-tuning the characteristics of ships being ordered and bought.

As the system is dynamic, and the feedback loop from operations to bank account is significantly shortened compared to industry standard way of negotiating such matters annually among the pool committee, the system encourages and incentives the whole system to constantly find better and more efficient ways of operation, as even slight incremental improvements have an effect. This is hoped to lead to a more attention towards regular hull cleanings and in the longer run greater interest from shipowners to invest ever-increasingly energy efficient ships and systems.

The proposed system is constructed with constraints of shipping pool in mind, which is the primary intended use. There should be no major obstacles to implement similar performance monitoring and benchmarking system to be used as an internal system for single shipowner, who is interested in optimising their fleet utilisation. As a result, the pool point system could be used as a basis for fleet management for single shipowner or for an internal performance-based personnel incentive plan. This would mean that the shipowner would form a virtual internal pool and use it to benchmark the monthly performance of ships' and use it as a basis for performance-based salary for officer's in the crew, operation and chartering departments – practice that is currently already in use, but the basis for the performance benchmarking might not be representative of the real world performance.

The proposed solution is constructed using virtual VLCC tanker pool as an example. There are no key aspects tied to a single cargo type – meaning that there are no restrictions of applicability related to ship type. In the case of other ship types, the cargo-related parameters, such as freight value, should be adjusted to represent the transportation work of said ship type. For example, in the case of volume-restricted cargo ships the proper selection of parameter should include the cargo volume instead of cargo mass, and a suitable metric to benchmark the market value of the contract instead of using WorldScale, which is tanker specific index.

7.1 FURTHER STUDIES

As some further study areas, the dynamic system should be tested and suitable parameters should be found for different ship types to widen the applicability to other ship types in markets where pooling is beneficial.

Another further study area would be a case study with an actual existing shipping pool, that is willing to hand out data – not only about its fleet operations but also about its freight contracts. This would help to validate and adjust the assumptions behind the distribution system for management. In the current state of preferred secrecy surrounding the industry the conflicts of interest related to this scenario are acknowledged, though.

Third further study area would be to research the operational profiles of ships against their design values. This is already done in some parts of the industry, but the results are not on many occasions publicly available.

7.2 FINAL WORDS

As a conclusion, this master's thesis manages to investigate and assess the complex and vaguely written discreet world of shipping pools and the distribution schemes embedded into them. The contribution of this work is to propose a basic idea of dynamic performance-based distribution scheme for bulk shipping pools based on the use of IMO's Energy Efficiency Operational Index, and manages to carry out the task with reasonable results.

The developed dynamic system acts as an extension to the current systems and replaces the speed and fuel consumption figures with the more relevant carbon efficiency in relation to transportation work done. It also proposes the inclusion of management into the profit-sharing system, which was not found in literature during the process of this study. The benefit of this is to incentivise all parties in the pool to strive for efficiency in their operations, and also make each part accountable in a meaningful and transparent way.

Even though the shipping pool distributions are a zero-sum game during a single month, for a longer period it is not. This is due to the simple fact that if one member raises its energy efficiency, thus reducing the amount of bunker fuel burned, it also reduces the amount of bunker the pool needs to buy, which means, ceteris paribus, that there will be more profit available in the pool. If all ships in the pool actively seek to improve their efficiency, not to cannibalise other members, but to increase their own share of profits, both the individual member and the whole pool are better of in the end.

While the industry clearly wants to maintain a shadow of secrecy around itself, the author strongly believes that open discussion would benefit both the single entities in the industry as well as the shipping industry as a whole.

8 REFERENCES

1. **IMO; Marine Environment Protection Committee.** *Reduction of GHG Emissions from Ships - Third IMO GHG Study 2014 - Final Report.* s.l. : IMO - International Maritime Organization, 2014.

2. **Kendall, Lane C and Buckley, James J.** *The Business of Shipping.* 7. Centreville, Maryland : Cornell Maritime Press, 2001.

3. **UNCTAD - United Nations Conference on Trade and Development.** *Chapter 1: Developments in International Seaborne Trade, Review of Maritime Transport 2014.* Geneva : United Nations Conference on Trade and Development, 2014.

4. **Gustaffson, Magnus, et al.** *Revolutionizing short sea shipping – Positioning Report.* Åbo Akademi University.

5. **Stopford, Martin.** *Maritime Economics.* 2nd. London : Routledge, 2003.

6. **Papachristidis, Basil Ph. and Papachristidis, Phrixos B.** Chapter 15 - Pools in International Shipping. [book auth.] O. Schinas and et al. (eds.). *HSBA Handbook on Shipping Finance.* Berlin : Springer-Verlag, 2015, pp. 269-281.

7. **Fearnley Consultants AS.** *EU Report - Legal and economic analysis of tramp maritime services.* s.l. : European Communities, 2007.

8. **Packard, William V.** *Shipping Pools.* 2. London : Lloyd's of London Press Ltd., 1995.

9. **Haralambides, Hercules E.** The Economics of Bulk Shipping Pools. *Maritime Policy & Management: The flagship journal of international shipping and port research.* 23 3 1996, Vol. 23, 3, pp. 221-237.

10. **IMO - International Maritime Organization.** Recycling of ships. [Online] [Cited: 8 11 2015.] http://www.imo.org/en/OurWork/Environment/ShipRecycling/Pages/Default.aspx.

11. **Stokes, Peter.** *Ship Finance - Credit Expansion and the Boom-Bust Cycle.* 1. London : Lloyd's of London Press Ltd., 1992.

12. **ICS - Institute of Chartered Shipbrokers.** *Shipping Business.* 3. London : Institute of Chartered Shipbrokers, 2014.

13. **UNCTAD - United Nations Conference on Trade and Development.** Data Center. *UNCTADSTAT.* [Online] [Cited: 15th December 2015.] unctadstat.unctad.org.

14. **Wiktionary.** tramp. *Wiktionary.* [Online] [Cited: 6 May 2015.] http://en.wiktionary.org/wiki/tramp.

15. **Online Etymology Dictionary.** tramp. *Online Etymology Dictionary.* [Online] [Cited: 6 May 2015.]

16. **Comission of The European Communities.** Draft Commission Regulation on the application of Article 85 (3) of the EC Treaty. *Official Journal of the European Communities.* 3 1994.

17. **Parkin, Michael, Powell, Melanie and Matthews, Kent.** Perfect Competition. *Economics.* 7th. Harlow : Pearson Education Limited, 2008, Vol. 11, pp. 249-262.

18. **U.S. Department of Transportation.** *Glossary of Shipping Terms 2008.* New Jersey : Maritime Administration, 2008.

19. **PotashCorp.** Phosphate - Overview. *PotashCorp.* [Online] http://www.potashcorp.com/overview/nutrients/phosphate/overview/world-phosphate-rock-trade.

20. **Visser, Auke.** Tanker List, status 01-01-2007. s.l. : International Super Tankers, 22 February 2007.

21. **Worlscale Association (London) Limited.** *NEW WORLDWIDE TANKER NOMINAL FREIGHT SCALE applying to the carriage of oil in bulk Code name "WORLDSCALE".* London : Worlscale Association, 2015.

22. *Long-term potential for increased shipping efficiency through the adoption of industry-leading practices.* **Wang, Haifeng and Lutsey, Nic.** s.l. : The International Council on Clean Transportation, 2013.

23. **International Maritime Organization (IMO).** International Convention for the Prevention of Pollution from Ships (MARPOL). [Online] [Cited: 20 October 2015.] https://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx.

24. *EEDI Absurdities.* **Devanney, Jack.** s.l. : Center for Tankship Excellence, USA, 2011.

25. **Parker, Sophia, et al.** *Understanding the Energy Efficiency Operational Indicator: An Empirical analysis from the Royal Belgian Shipowners' Association.* UCL Energy Institute. s.l. : Royal Belgian Shipowners' association, 2015.

26. *Designing Ships for Service with the Help of Performance Monitoring.* **Furustam, J., et al.** s.l. : The Royal Institution of Naval Architects, 2015. International Conference on Computer Applications in Shipbuilding 2015.

27. **OAPEC - Organization of Arab Petroleum Exporting Countries.** Spot tanker crude freight rates. *Monthly Bulletin.* 11 2015, Vol. 41, 11.

28. **Statista.** OPEC basket crude oil price development from October 2014 to October 2015 (in U.S. dollars per barrel). *Statista - The Statistics Portal.* [Online] Statista GmbH. [Cited: 10 12 2015.] http://www.statista.com/.

29. **Clarkson Research Services.** Offshore Intelligence Monhtly. April 2015, Vol. 5, 4.

Appendix A. EXAMPLE OF A DISTRIBUTION FOR A CHEMICAL TANKER POOL

Age	*2%*
DWT	*5%*
Cargo cubic capacity	*65%*
Stainless steel	*10%*
IMO I class	*3%*
IMO II class	*2%*
IMO III class	*1%*
Segregates	*2%*
Ice class	*2%*
NRT/GRT	*2%*
Speed and consumption	*4%*
Heat zones	*2%*

The allocation of values within each parameter shall take place as follows:

For Age:	*Less than 15 years*	*100*
	15-20 years	*50*
	More than 20 years	*25*

For DWT $$DWT = \frac{Vessel's\ dwt}{Reference\ ship's\ dwt} * 100$$

For cubic cargo capacity $$CCC_i = \frac{Vessel's\ capacity}{Reference\ ship's\ capacity} * 100$$

For Stainless Steel cargo capacity $$CCC_{SS} = \frac{Vessel's\ SS\ capacity}{Reference\ ship's\ SS\ capacity} * 100$$

For each IMO Class $$CCC_{IMOi} = \frac{Vessel's\ IMOi\ capacity}{Reference\ ship's\ IMOi\ capacity} * 100$$

No of Segregates $$SEGR = \frac{Vessel's\ number\ of\ segragates}{Reference\ ship's\ number\ of\ segragates} * 100$$

Ice class *1A Super: 150*
1A: 100
1B: 50

NRT/GRT $$NRT/GRT = \frac{Vessel's\ {}^{NRT}/_{GRT}}{Reference\ ship's\ {}^{NRT}/_{GRT}} * 100$$

Speed and consumption $$\$/tonmile = \frac{Vessel's\ \$/tonmile}{Reference\ ship's\ \$/tonmile} * 100$$
(The relative cost of transporting one ton of cargo)

Heat zone $$HeatZones = \frac{Vessel's\ \frac{cubic\ capacity\ with\ three\ heat\ zones}{total\ cubic\ capacity}}{Reference\ ship's\ \frac{cubic\ capacity\ with\ three\ heat\ zones}{total\ cubic\ capacity}} * 100$$

Appendix B. VLCC POOL PERFORMANCE ASSESSMENT REPORTS

Performance assessments for the ships in the VLCC Pool, according to the example of Packard (7).

Year		**2015**	**Months**	**1-9**						
Currency		**$**								
Vessel		**A**								
Owner		**1**								
Month		**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Days at sea laden		23,1	13,5	29,0	6,1	27,5	-0,1	0,0	0,0	12,7
Adverse weather		0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Laden Days		23,1	13,5	29,0	6,1	27,5	0,0	0,0	0,0	12,7
Days at Sea Ballast		-0,3	4,7	0,1	10,3	-0,1	23,0	0,0	0,0	0,0
Navigating restrictions	neglected									
Ballast Days		0,0	4,7	0,1	10,3	0,0	23,0	0,0	0,0	0,0
Days in Port		7,8	9,5	1,8	9,1	3,4	6,9	6,3	0,0	0,0
Operating Days		29,7	26,7	30,6	23,5	30,4	29,4	6,3	0,0	12,5
Missing data points	84,0									
Bunker Grade	f/o 180 c/s									
Target Speed	Laden	13	13	13	13	13	13	13	13	13
	Ballast	11	11	11	11	11	11	11	11	11
Consumption										
Vessel	Laden	85,87	85,87	85,87	85,87	85,87	85,87	85,87	85,87	85,87
	Ballast	52,28	52,28	52,28	52,28	52,28	52,28	52,28	52,28	52,28
Vessel Days	Laden	23,08	13,50	28,96	6,13	27,50	0,00	0,00	0,00	12,67
	Ballast	0,00	4,67	0,13	10,29	0,00	23,00	0,00	0,00	0,00
Reference Model	Consumption	106	106	106	106	106	106	106	106	106
	Days	23,1	18,2	29,1	16,4	27,5	23,0	0,0	0,0	12,7
Total Consumption	Vessel	1982	1403	2493	1064	2362	1202	0	0	1088
	Model	2442	1922	3077	1737	2910	2433	0	0	1340
Assessment										
Bunker Grade	f/o 180 c/s									
Saved/Lost (-)		460	519	584	673	548	1231	0	0	252
Monthly Average Price		44,38	54,06	52,46	57,3	62,16	60,21	54,19	45,46	44,83
Total		$20 413	$28 045	$30 621	$38 557	$34 061	$74 121	$-	$-	$11 315
$237 133										

Year		**2015**	**Monts**		**1-9**					
Currency		**$**								
Vessel		**B**								
Owner		**1**								
Month		**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Days at sea laden		12,6	27,9	7,5	22,3	19,0	17,5	20,0	11,3	6,3
Adverse weather		0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Laden Days		12,6	27,9	7,5	22,3	19,0	17,5	20,0	11,3	6,3
Days at Sea Ballast		1,4	0,0	5,2	0,0	2,2	5,3	1,6	12,2	16,4
Navigating restrictions	neglected									
Ballast Days		1,4	0,0	5,2	0,0	2,2	5,3	1,6	12,2	16,4
Days in Port		16,4	0,1	18,1	7,5	9,1	6,5	9,0	7,0	6,6
Operating Days		28,4	27,8	30,3	29,2	28,8	28,4	29,7	29,4	27,6
Missing data points	13,3									
Bunker Grade	f/o 180 c/s									
Target Speed	Laden	13	13	13	13	13	13	13	13	13
	Ballast	12	12	12	12	12	12	12	12	12
Consumption										
Vessel	Laden	79,51	79,51	79,51	79,51	79,51	79,51	79,51	79,51	79,51
	Ballast	60,95	60,95	60,95	60,95	60,95	60,95	60,95	60,95	60,95
Vessel Days	Laden	12,63	27,88	7,50	22,29	19,04	17,50	20,04	11,25	6,29
	Ballast	1,42	0,00	5,21	0,04	2,17	5,29	1,63	12,21	16,42
Reference Model	Consumption	106	106	106	106	106	106	106	106	106
	Days	14	28	13	22	21	23	22	23	23
Total Consumption	Vessel	1090	2216	914	1775	1646	1714	1693	1639	1501
	Model	1486	2949	1345	2363	2244	2411	2292	2482	2403
Assessment										
Bunker Grade	f/o 180 c/s									
Saved/Lost (-)		395	733	431	588	598	697	600	843	902
Monthly Average Price		44,38	54,06	52,46	57,3	62,16	60,21	54,19	45,46	44,83
Total		$17 551	$39 619	$22 598	$33 689	$37 159	$41 991	$32 503	$38 336	$40 422
$303 868										

Year		**2015**		**Months**	**1-9**					
Currency		**$**								
Vessel		**C**								
Owner		**2**								
Month		**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Days at sea laden		8,6	0,0	1,5	12,4	4,0	13,0	20,5	22,1	-0,1
Adverse weather		0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Laden Days		8,6	0,0	1,5	12,4	4,0	13,0	20,5	22,1	0,0
Days at Sea Ballast		0,0	0,0	6,7	11,7	17,1	-0,2	1,3	0,0	2,3
Navigating restrictions	neglected									
Ballast Days		0,0	0,0	6,7	11,7	17,1	0,0	1,3	0,0	2,3
Days in Port		0,1	0,0	0,0	5,6	8,7	13,8	9,0	0,0	2,0
Operating Days		8,5	0,0	8,0	28,7	28,8	25,4	30,1	22,0	3,8
Missing data points	117,7									
Bunker Grade	f/o 180 c/s									
Target Speed	Laden	14	14	14	14	14	14	14	14	14
	Ballast	15	15	15	15	15	15	15	15	15
Consumption										
Vessel	Laden	113,46	113,46	113,46	113,46	113,46	113,46	113,46	113,46	113,46
	Ballast	73,28	73,28	73,28	73,28	73,28	73,28	73,28	73,28	73,28
Vessel Days	Laden	8,63	0,00	1,54	12,38	4,00	13,00	20,54	22,08	0,00
	Ballast	0,00	0,00	6,67	11,71	17,08	0,00	1,25	0,00	2,33
Reference Model	Consumption	106	106	106	106	106	106	106	106	106
	Days	9	0	8	24	21	13	22	22	2
Total Consumption	Vessel	979	0	663	2262	1706	1475	2422	2506	171
	Model	913	0	868	2548	2231	1375	2306	2336	247
Assessment										
Bunker Grade	f/o 180 c/s									
Saved/Lost (-)		-66	0	205	286	525	-100	-117	-169	76
Monthly Average Price		44,38	54,06	52,46	57,3	62,16	60,21	54,19	45,46	44,83
Total		$- 2 931	$-	$10 754	$16 388	$32 630	$- 5 993	$- 6 320	$- 7 687	$3 402
$40 243										

Year		**2015**		**Months**	**1-9**					
Currency		**$**								
Vessel		**D**								
Owner		**2**								
Month		**Jan**	**Feb**	**Mar**	**Apr**	**Ma y**	**Jun**	**Jul**	**Aug**	**Sep**
Days at sea laden		-0,1	0,0	0,2	15,3	7,1	12,1	18,0	2,4	17,0
Adverse weather		0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Laden Days		0,0	0,0	0,2	15,3	7,1	12,1	18,0	2,4	17,0
Days at Sea Ballast		5,8	0,0	10,9	6,9	16,3	9,6	8,3	18,3	-0,1
Navigating restrictions	neglected									
Ballast Days		5,8	0,0	10,9	6,9	16,3	9,6	8,3	18,3	0,0
Days in Port		4,3	0,0	3,5	7,5	7,1	5,0	4,3	10,1	12,8
Operating Days		9,7	0,0	14,4	28,7	29,0	26,3	29,5	30,2	28,9
Missing data points	76,4									
Bunker Grade	f/o 180 c/s									
Target Speed	Laden	13	13	13	13	13	13	13	13	13
	Ballast	14	14	14	14	14	14	14	14	14
Consumption										
Vessel	Laden	110,64	110,6 4	110,64	110,64	110,64	110,64	110,64	110,64	110,64
	Ballast	125,28	125,2 8	125,28	125,28	125,28	125,28	125,28	125,28	125,28
Vessel Days	Laden	0,00	0,00	0,17	15,33	7,08	12,13	18,00	2,42	16,96
	Ballast	5,75	0,00	10,88	6,92	16,29	9,58	8,25	18,33	0,00
Reference Model	Consumption	106	106	106	106	106	106	106	106	106
	Days	6	0	11	22	23	22	26	21	17
Total Consumption	Vessel	720	0	1381	2563	2825	2542	3025	2564	1876
	Model	608	0	1168	2354	2473	2297	2777	2195	1794
Assessment										
Bunker Grade	f/o 180 c/s									
Saved/Lost (-)		-112	0	-213	-209	-352	-245	-248	-369	-82
Monthly Average Price		44,38	54,06	52,46	57,3	62,16	60,21	54,19	45,46	44,83
Total		$- 4 970	$-	$- 11 153	$- 11 972	$- 21 855	$- 14 772	$- 13 429	$- 16 764	$- 3 680

$-98 595

Year **2015** **Months** **1-9**

Currency **$**

Vessel **E**

Owner **2**

Month		**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Days at sea laden		2,0	0,2	5,7	2,6	13,4	13,8	7,1	2,1	10,6
Adverse weather		0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Laden Days		2,0	0,2	5,7	2,6	13,4	13,8	7,1	2,1	10,6
Days at Sea Ballast		0,0	0,0	0,0	17,4	9,7	4,4	17,0	0,0	5,8
Navigating restrictions	neglected									
Ballast Days		0,0	0,0	0,0	17,4	9,7	4,4	17,0	0,0	5,8
Days in Port		0,0	3,0	1,0	9,7	7,7	8,5	6,6	0,0	4,3
Operating Days		1,8	3,0	6,5	28,9	29,9	26,1	29,9	2,1	19,6
Missing data points	125,1									
Bunker Grade	f/o 180 c/s									
Target Speed	Laden	14	14	14	14	14	14	14	14	14
	Ballast	16	16	16	16	16	16	16	16	16
Consumption										
Vessel	Laden	142,67	142,67	142,67	142,67	142,67	142,67	142,67	142,67	142,67
	Ballast	151,12	151,12	151,12	151,12	151,12	151,12	151,12	151,12	151,12
Vessel Days	Laden	2,04	0,21	5,71	2,63	13,38	13,83	7,13	2,13	10,58
	Ballast	0,00	0,00	0,00	17,42	9,67	4,42	16,96	0,00	5,79
Reference Model	Consumption	106	106	106	106	106	106	106	106	106
	Days	2	0	6	20	23	18	24	2	16
Total Consumption	Vessel	291	30	814	3007	3369	2641	3579	303	2385
	Model	216	22	604	2120	2438	1931	2548	225	1732
Assessment										
Bunker Grade	f/o 180 c/s									
Saved/Lost (-)		-75	-8	-210	-886	-931	-710	-1031	-78	-653
Monthly Average Price		44,38	54,06	52,46	57,3	62,16	60,21	54,19	45,46	44,83
Total		$-3 341	$-415	$-11 042	$-50 776	$-57 888	$-42 763	$-55 886	$-3 562	$-29 261

$-254 935

Appendix C. Ship and management monthly pool point figures

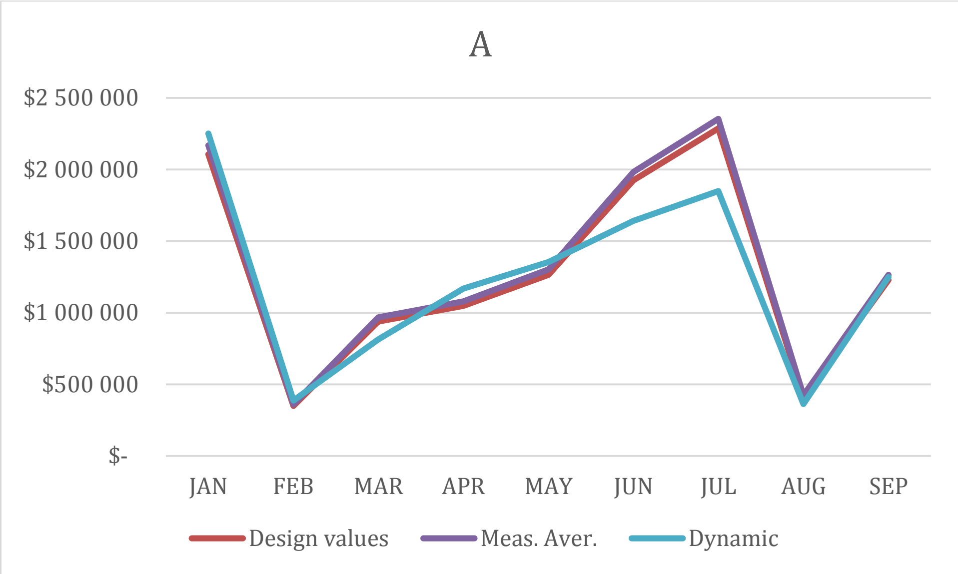


Figure C. 1 Monthly revenue for ship A with pool income as a function of estimated freight value.

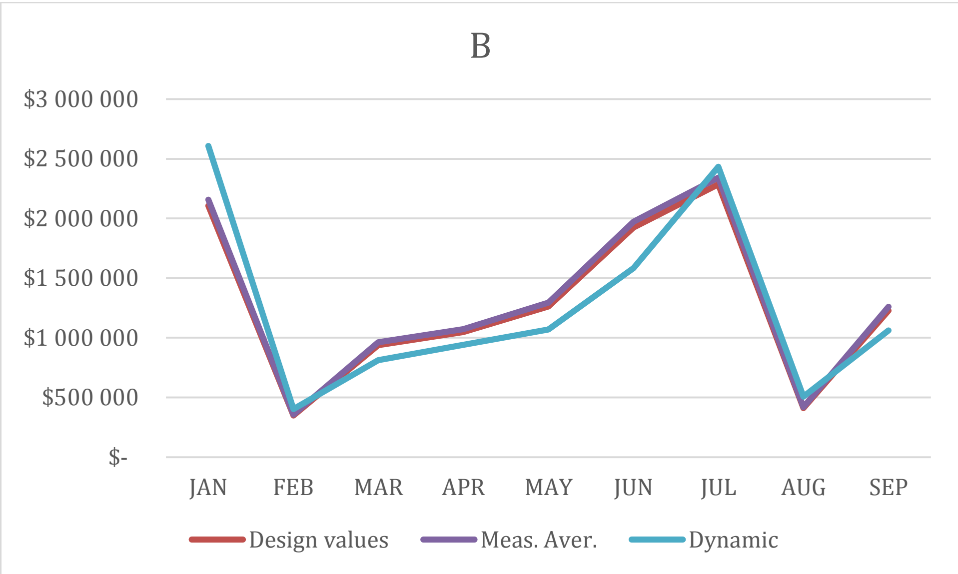


Figure C. 2 Monthly revenue for ship B with pool income as a function of estimated freight value.

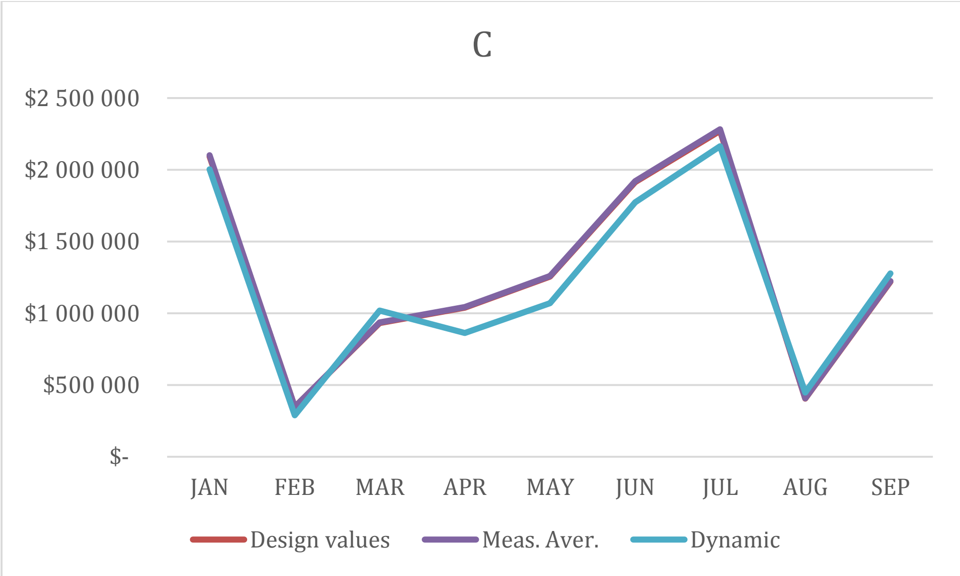


Figure C. 3 Monthly revenue for ship C with pool income as a function of estimated freight value.

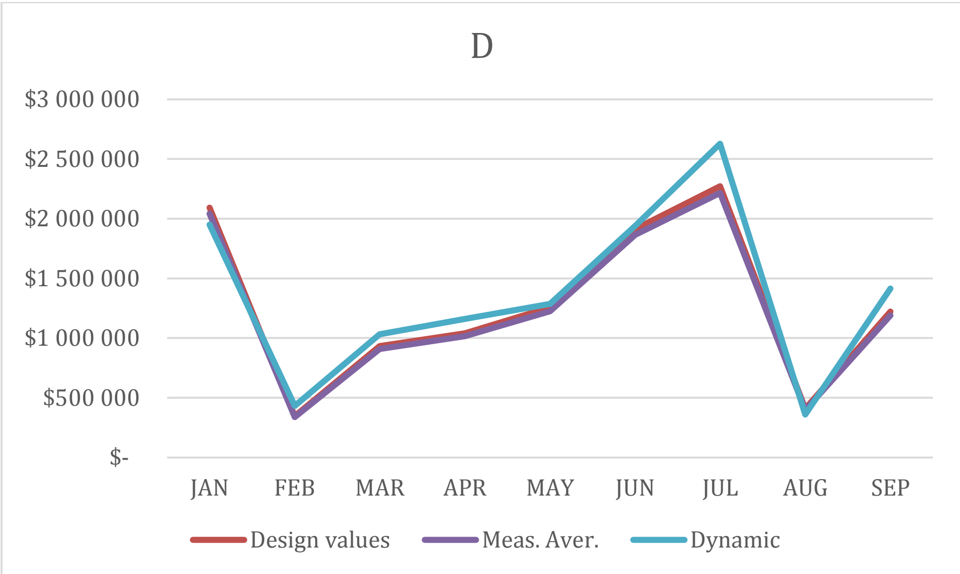


Figure C. 4 Monthly revenue for ship D with pool income as a function of estimated freight value.

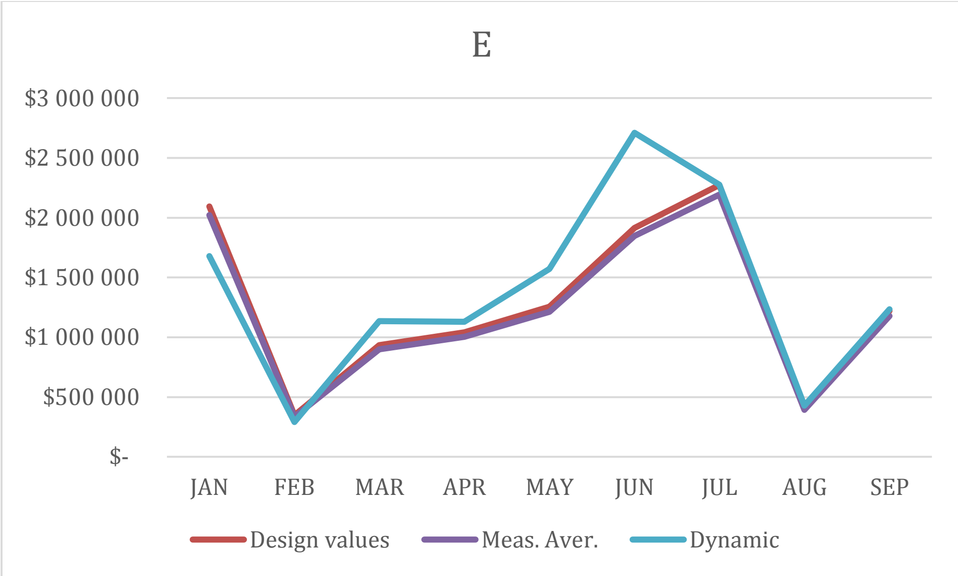


Figure C. 5 Monthly revenue for ship E with pool income as a function of estimated freight value.

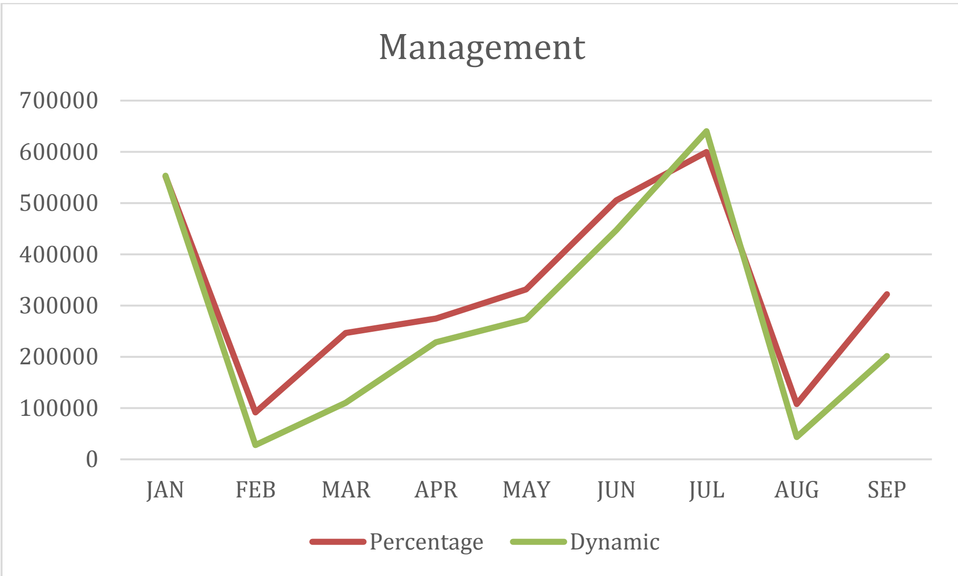


Figure C. 6 Monthly profit for Management with pool income as a function of estimated freight value.